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LATE CRETACEOUS AND PALEOCENE MAMMALS FROM SOUTHWESTERN SASKATCHEWAN

by

Paul A. Johnston

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled LATE CRETACEOUS AND PALEOCENE MAMMALS FROM SOUTHWESTERN SASKATCHEWAN submitted by Paul A. Johnston in partial fulfilment of the requirements for the degree of Master of Science.

Richard C. Fox
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Date 26 May 1980

ABSTRACT

The Frenchman and Ravenscrag formations of southwestern Saskatchewan document apparently continuous deposition of continental clastic sediments during latest Cretaceous and earliest Tertiary time. Exposed section of the Ravenscrag Formation occurs in a commercial clay quarry near the village of Ravenscrag, and has yielded mammalian remains from two horizons: the upper horizon (designated Rav W-1) is of early Paleocene (Puercan) age; the lower horizon (designated Long Fall) occurs at the base of the formation, 3.1 meters directly below the Rav W-1 horizon and is of latest Cretaceous (Lancian) age. The presence of Lancian fossils at Long Fall extends the time interval represented by the Ravenscrag Formation to include latest Cretaceous time.

Another mammal-bearing locality (designated Croc Pot), of Puercan age, occurs within the buff phase of the Ravenscrag Formation to the west of Rav W-1 and Long Fall and indicates the upper part of the Ravenscrag Formation in the vicinity of Ravenscrag and Eastend is likely no younger than about mid-Torrejonian at latest. Taxa represented at Rav W-1 (except insectivorans) and Long Fall are described. New taxa named from Rav W-1 include new species of: Parectypodus, Neoplagiaulax, Stygimys, Microcosmodon (Multituberculata); Oxyclaenus, Loxolophus, Litomylus, and a new genus and species of mioclaenid (Condylarthra). A new species of the giant multituberculate Taeniolabis that is apparently more primitive than Taeniolabis taoensis of the type Puercan is present at Rav W-1 but is not named. A relatively derived taeniolabid multituberculate and several relatively derived condylarths are present at Long Fall, but no new taxa are named. Taxonomic composition of the

Mammalia of the Rav W-1 assemblage appears most similar to that of Garbani Quarry and, to a lesser degree, Purgatory Hill (both Puercan, Tullock Formation, Montana); that of Long Fall appears most similar to assemblages at Hell's Hollow (earliest Paleocene, Tullock Formation, Montana). Rav W-1 likely pre-dates the Taeniolabis-zone of the Puercan interval of the Nacimiento Formation of the San Juan Basin, New Mexico.

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INTRODUCTION

The Frenchman and Ravenscrag formations outcrop intermittently in a broad band extending across southern Saskatchewan and southeastern Alberta. These formations document apparently continuous deposition of continental clastic sediments during latest Cretaceous and earliest Tertiary time. Extensive exposures of the Ravenscrag and Frenchman formations (including the type areas) occur along the walls of the valley of the Frenchman River, on the southeast flank of the Cypress Hills, in the vicinity of the village of Ravenscrag and the town of Eastend in southwestern Saskatchewan. Late Cretaceous and early Paleocene fossil mammals recovered from this area are the focus of the present study.

Previous investigations: The occurrence of non-mammalian vertebrate fossils (in particular dinosaurs, including Triceratops) of Lancian age in the Frenchman Formation has long been known (Dawson 1895 in Sternberg 1924), and was taken to indicate equivalence of the Frenchman Formation with the Hell Creek Formation of Montana (McLearn in Fraser et al. 1935). Mammalian fossils, however, remained unknown until 1977, when a University of Alberta field party discovered a site (designated Frenchman - 1) near the village of Ravenscrag yielding a small sample of mammal teeth (Johnston 1980). These proved to be of biostratigraphic interest: the taxa present (in particular the primitive ungulate Protungulatum Sloan and Van Valen 1965) documented the occurrence here of the Bug Creek faunal facies (Archibald 1977), known elsewhere only from certain assemblages of Paleocene aspect in the Upper Cretaceous Hell Creek Formation of Garfield and McCone counties, Montana (Sloan and Van Valen 1965; Archibald 1977).

The Ravenscrag Formation, which conformably overlies the Frenchman Formation, was long suspected to be of Paleocene age, primarily from the absence of dinosaur remains (Russell 1951) and the presence of certain fossil plants (Bell in McLearn 1928; Berry 1935) and non-marine molluscs (Russell 1932) that are similar to those of the Fort Union Group of North Dakota and Montana (McLearn 1928, 1929, 1930; Russell 1965a). It was not clear, however, how much of Paleocene time the Ravenscrag Formation represents: mammalian remains eluded collectors, precluding correlation with the well documented mammalian succession from Paleocene strata of the Western Interior of the United States.

McLearn (1928) suspected the Ravenscrag Formation of southwestern Saskatchewan is of Puercan (early Paleocene) age and a correlative of the Tullock of Montana and possibly the Puerco of New Mexico. Sternberg (1932) believed that a crocodile skull (Leidyosuchus acutidentatus Sternberg 1932), recovered from the upper half of the Ravenscrag Formation in southcentral Saskatchewan, supported this view: the species was thought to be intermediate between a species from the Cretaceous Lance Formation of Wyoming and one from the middle Paleocene Torrejon of New Mexico. The value, however, of species of Leidyosuchus as indicators of geologic age is questionable, so that the time span represented by the Ravenscrag Formation remained in dispute (McLearn in Fraser et al. 1935). Subsequent writers believed the Ravenscrag Formation of southwestern Saskatchewan represents most of Paleocene time and that the upper part of the formation is equivalent to the Tongue River (Russell 1932, 1950) and Sentinel Butte (Kupsch 1956; Guliov 1972) formations, both of late Paleocene age.

The first mammalian remains from the Ravenscrag Formation were

collected by UA field parties at the Police Point locality in the Cypress Hills of Alberta. Krishtalka described the mammals, which proved to be of middle or late Tiffanian (late Paleocene) age (Krishtalka 1973; Krause 1978). Krishtalka (1973: 7) pointed out that "correlation of the Alberta Ravenscrag with the type section of that formation in Saskatchewan has never been demonstrated by continuous mapping"; furthermore, the lithology is rather different from the type Ravenscrag, so that it is not clear whether the units of the Alberta side truly pertain to the Ravenscrag Formation. The Police Point mammals are consequently of little value in elucidating the time interval represented by Ravenscrag strata on the Saskatchewan side.

The first fossil mammals from the Ravenscrag of Saskatchewan were recovered from about the middle of the formation at the Pine Cree locality southwest of Shaunavon (Russell 1974) and consisted of a single jaw fragment (upon which Russell named a new species of condylarth, Carcinodon aquilonius) along with some unidentifiable post-cranial elements. The jaw fragment was sufficient to establish a Puercan age for at least that part of the Ravenscrag Formation, and was the first mammal of Puercan age recognized from Canada. In actuality, a dentary fragment from a well core in Alberta that was described as Prothryptacodon albertensis Fox 1968 (and subsequently synonomized with C. aquilonius, the former having priority, and placed in a new genus Oxyprimus Van Valen 1978) is also likely of Puercan age, although not originally recognized as such (see p. 130 for discussion).

A series of rich late Tiffanian mammal-bearing localities in the Ravenscrag Formation from near Roche Percee, southeastern

Saskatchewan, was discovered in 1971 and was reported by Krause (1977;1978). The Roche Percee localities cannot be contemporaneous with strata in the type area of the Ravenscrag, as those localities are significantly higher in the section (Whitaker 1978: pl. 2).

New discoveries: During the summer of 1974, Mrs. L. O. Lindoe of Medicine Hat, Alberta, discovered fossil scales of the gar-pike Lepisosteus on a grassy slope adjacent to a commercial clay quarry, about 3.5 km WNW of the village of Ravenscrag, in southwestern Saskatchewan. Mr. L. A. Lindoe (Chief Preparator in Vertebrate Paleontology, University of Alberta) collected two sacks of sediment from the face of the slope and brought them to Sandy Point, Alberta, where a University of Alberta field crew, under the supervision of Dr. R. C. Fox, was conducting washing and screening operations for the recovery of Late Cretaceous microvertebrates. Upon processing the Saskatchewan sample a variety of small vertebrate fossils (but no mammals) were recovered. Toward the end of that summer, Dr. Fox visited the Saskatchewan site, which he designated Rav W-1, and discovered the first mammalian fossils there, near the base of the Ravenscrag Formation.

During the summer of 1975, a large collection of fossiliferous sediment was quarried from Rav W-1 by University of Alberta field crews and transported to near Milk River, Alberta, where it was screened under water (for description of procedure, see McKenna 1960, Clemens 1963, Lillegraven 1969). In August 1976 a second large sample was quarried from Rav W-1 and was processed in the laboratory. Both 18 mesh and 40 mesh per inch screen was used. These collections yielded fragmentary remains of a variety of vertebrates, including actinopterygian

fishes, frogs, salamanders, turtles, champsosaurs, lizards, crocodiles, birds and mammals. Subsequent study has revealed that these fossils are of early Paleocene age.

Commercial excavation in the clay quarry during 1977 and 1978 destroyed the fossiliferous layers of Rav W-1. A few samples were taken from spill piles in 1977, but yields were poor. In 1979, however, it was found that, although the commercial clay operation had destroyed the Rav W-1 layers, it had exposed a new fossiliferous lens, 3.4 meters below the level of Rav W-1 but in the same lithologic unit; this new horizon has been designated "Long Fall." The Long Fall lens, a small sample of which has been processed in the laboratory, is of Late Cretaceous age and will continue to be worked in upcoming field seasons. Intensive prospecting during the summer of 1977 in the Frenchman River valley in the general vicinity of Ravenscrag and Eastend resulted in the discovery of several other fossiliferous localities of Late Cretaceous age and one of early Paleocene age; these new sites have not yet been extensively sampled. The present study should therefore be regarded as a preliminary investigation of Late Cretaceous and early Paleocene mammalian evolution and biostratigraphy as documented in strata of southwestern Saskatchewan.

ABBREVIATIONS

Abbreviations used in the text are as follows:

(a) Dentitions:

I,i -- upper or lower incisor respectively.

M,m -- upper or lower molar respectively.

P,p -- upper or lower premolar respectively.

(b) Measurements:

Multituberculate p4's only (Novacek and Clemens 1977:704)

h -- "...measured from the highest point of the crest to the baseline".

Ll -- "...parallel to B (baseline), is measured from the anterior edge of the blade to a point directly below its highest point".

General:

Ant-W -- anterior width.

L -- length.

Max-D -- maximum diameter.

Min-D -- minimum diameter.

Post-W -- posterior width.

Tal-W -- talonid width.

Tri-W -- trigonid width.

W -- width.

(c) Statistics:

CV -- coefficient of variation.

M -- mean.

N -- sample size.

OR -- observed range.

SD -- standard deviation.

SE -- standard error.

(d) Localities

BCA -- Bug Creek Anthills

(e) Institutions

AMNH -- American Museum of Natural History.

KU -- The University of Kansas.

LACM -- Los Angeles County Museum of Natural History

ROM -- Royal Ontario Museum.

UA -- The University of Alberta.

UCMP -- University of California Museum of Paleontology, Berkeley.

UM -- University of Michigan.

USNM -- United States National Museum.

MEASUREMENTS, PROCEDURES AND TERMINOLOGY

All measurements are in millimeters and were made with an ocular micrometer disc inserted into the eyepiece of a Wild M7 dissecting microscope. Measurements of multituberculate p4's follow Novacek and Clemens (1977). Determination of width of multituberculate p4's is omitted owing to the difficulty of consistent orientation and the limitations of the optical equipment at hand. Nomenclature for multituberculate dentitions and measurements of multituberculate teeth other than p4 follow Simpson (1937), Jepsen (1940) and Krause (1977). Measurement of the height of the first serration follows Schiebout (1974). The p4's of certain multituberculate species often bear a variably developed projection of the enamel on the median ridge at the anterior end of the apical crest. It is generally a subjective decision as to whether this projection, if present, is of sufficient stature to be regarded as a serration and included in serration enumeration. I regard this projection as a serration only if it bears at least one lateral ridge; when lateral ridges are lacking I term this projection, "incipient serration" and omit it from serration counts. The construction and superimposition of lateral profiles of multituberculate p4's follow Jepsen (1940) and Krause (1977).

Measurements of therian dentitions were made as by Clemens (1966); terminology follows Schiebout (1974: fig. 48). The term "medial" where used refers to position near the anteroposterior axis of lower teeth and the transverse axis of upper teeth.

Measurements of the section exposed on the nearly vertical quarry wall at Rav W-1 were made with a hand-held meter stick on that part of the section that was accessible; non-accessible parts of the section were

measured from photographs with a known scale. Measurement of the section at Croc Pot was done without a level and was rechecked against photographs but is likely imprecise. Correlation of sections in Fig. 5, however, is based on gross lithologic features rather than on precise thicknesses of strata and resulting interpretations are such that they would not be altered by any inaccuracies of measurement incurred.

GEOLOGICAL SETTING

Strata exposed in the valley of the Frenchman River and its tributaries in the vicinity of Ravenscrag and Eastend are arranged as follows, beginning with the lowest horizons:

Bearpaw Formation: Outcrops of the Bearpaw are not extensive in the Ravenscrag-Eastend area and occur only where fluviatile erosion has penetrated deeply enough to expose the upper part of the formation (Kupsch 1956). The Bearpaw consists primarily of dark marine shales and has yielded a marine fauna of Late Cretaceous age (Russell 1965).

Eastend Formation: The lower portion of the Eastend consists of "brownish gray fine-grained sand, silt, and silty clay" and the upper portion "of greenish-yellow, fine grained sand, silt and very thin beds of lignite" (Whitaker 1978: 23). The lower beds are apparently transitional between the marine sands and shales of the underlying Bearpaw and the non-marine flood-plain sands and silts of the upper part of the Eastend and the overlying Whitemud Formation (Byers 1969: 331). The Eastend Formation has yielded marine pelecypods from one locality (Russell 1943) and fragmentary fish remains from another (unpublished, collected by UA field party in 1979).

Whitemud Formation: The Whitemud Formation consists primarily of interbedded non-marine, kaolinitic sands, silts and clays with a carbonaceous layer at about the middle of the unit (Kupsch 1956; Byers 1969). The Whitemud has yielded plant megafossils indicative of low-lying marshy areas (Berry 1935).

Battle Formation: The Battle Formation consists primarily of dark shale and was earlier regarded as a zone of the Whitemud Formation (McLearn in Fraser et al. 1935) but was later given formational status

(Furnival 1946). I know of no diagnostic megafossils that have been recovered from the Battle Formation, but Foraminifera have been reported (Crockford and Clow 1965 in Byers 1969), indicating marine deposition for at least some of the formation. Kupsch (1956) regards strata of Battle character lying on the Whitemud Formation in the vicinity of Eastend and Ravenscrag, to represent the clay phase of the Frenchman Formation rather than the Battle Formation. Kupsch points out that there is evidence in this area that Battle-like sediments are separated from the Whitemud by an erosional unconformity and are conformable with the overlying Frenchman Formation.

Frenchman Formation: Two lithologic phases characterize the Frenchman Formation (Russell 1950; Kupsch 1956): a sand phase consisting of a medium-to fine-grained, generally unconsolidated, lithic sand locally bearing large log-like indurated masses, and a clay phase consisting of grey, greyish-green to purplish bentonitic clays. The sand phase can lie below (McLearn in Fraser et al. 1935), at the same level as, or above the clay phase (Russell 1950; Kupsch 1957). The Frenchman Formation, ranging in thickness from 9-67 m, is thinnest west of Eastend and thickens eastward (Misko and Hendry 1979). The base ofthe Frenchman Formation is marked by a disconformity with underlying Cretaceous strata (but see Kupsch 1956 concerning contact with the Battle Formation). In the vicinity of Ravenscrag village, the Frenchman Formation rests on either the Battle or Whitemud Formation, but to the southeast it cuts down into progressively older strata, including the Eastend and Bearpaw formations (Russell 1950).

Ravenscrag Formation: In southwestern Saskatchewan, the Ravenscrag Formation consists of up [redacted]150 m of fine-grained sands, clays,

shales and lignites (Russell 1974). The formation includes two lithologic phases, a lower grey phase and an overlying buff phase, although this subdivision has not been given formal status. The contact of the Ravenscrag Formation with the underlying Frenchman Formation is conventionally recognized as occurring at the base of the lowest prominent lignite, which is known locally as the Ferris or No. 1 seam.

Cypress Hills Formation: Sandstone and conglomerate of the Cypress Hills Formation overlie the Ravenscrag Formation and have yielded a rich Oligocene mammalian fauna (Russell 1965).

The post-Bearpaw and pre-Cypress Hills sediments described above, are thought to represent primarily alluvial flood-plain deposits (except the lower Eastend and Battle) (Byers 1969). These strata are all of Late Cretaceous age, except the Ravenscrag Formation, which is regarded as Paleocene (but see p. 29 below). Regional correlation of these units, as viewed by most previous authors, is given in Fig. 1, but see p. 29 below concerning the duration in time represented by the Ravenscrag Formation.

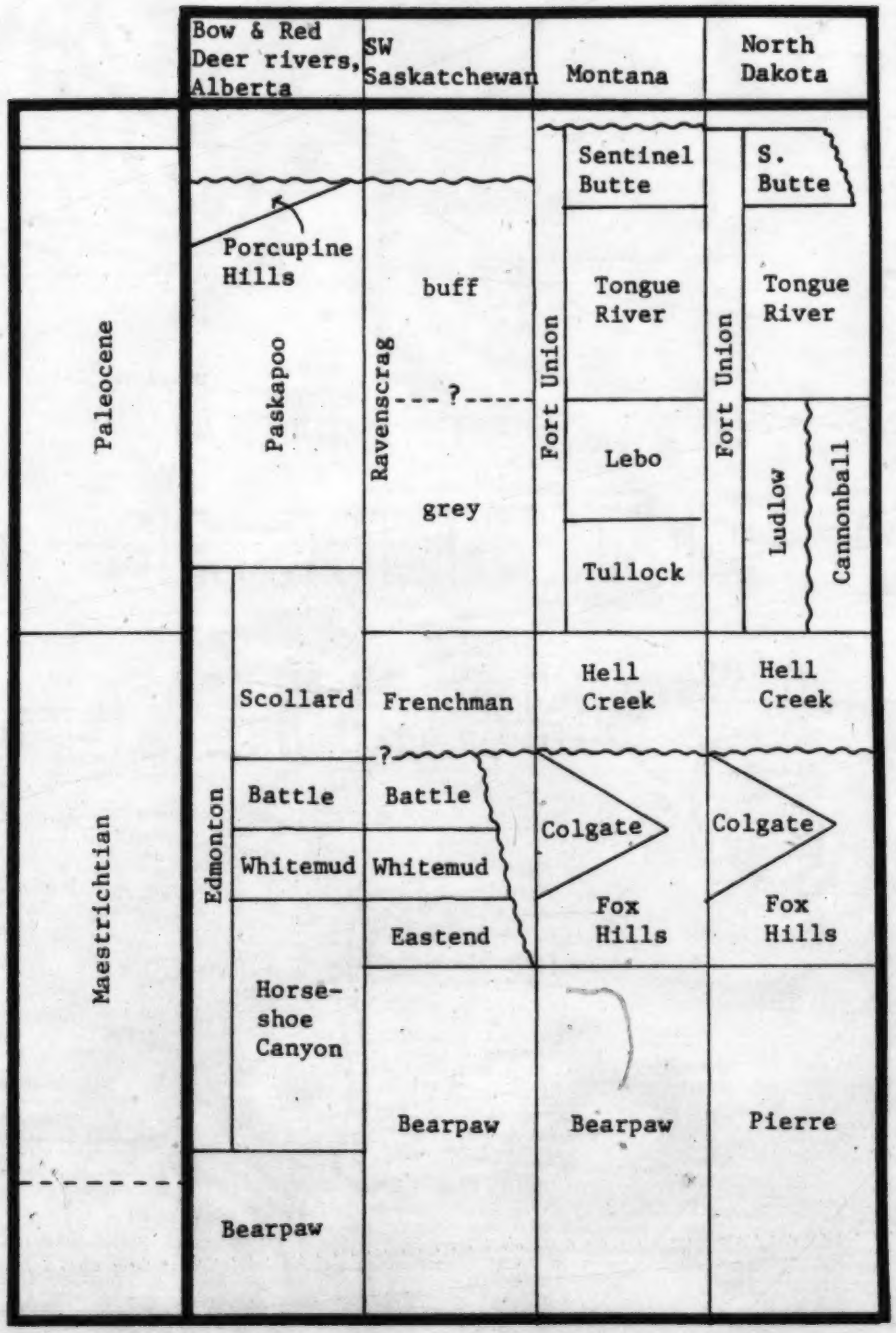


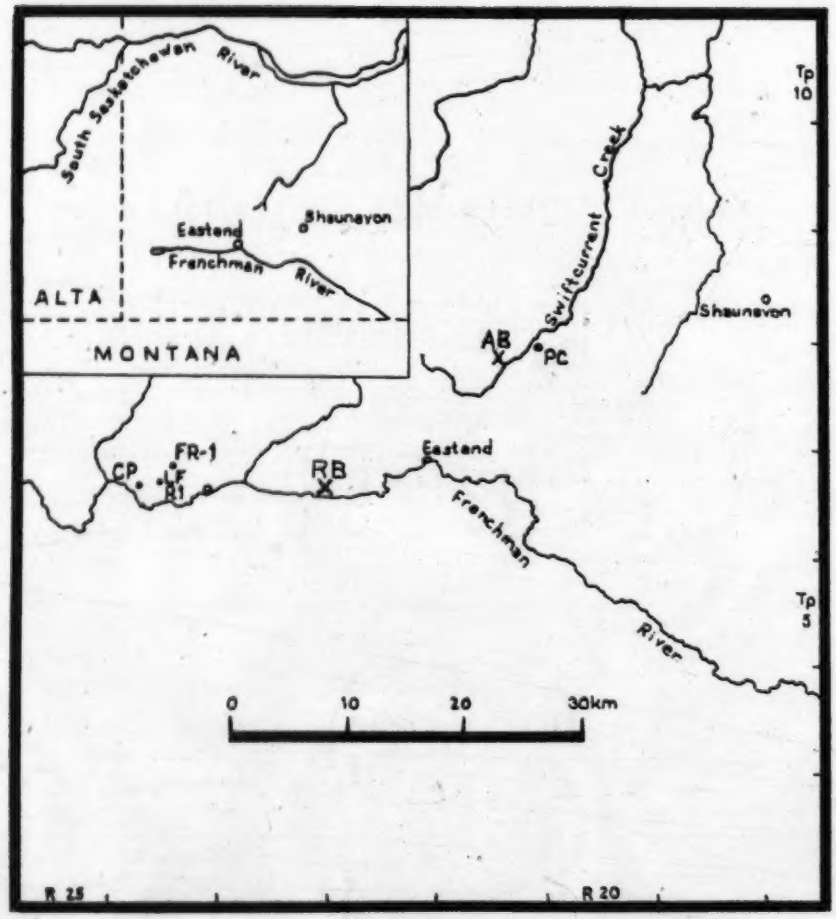
Figure 1. Regional correlation chart (modified after Kupsch 1956; Byers 1969; Guliov 1972; Rahmani and Lerbekmo 1975; Misko and Hendry 1979).

DESCRIPTION OF LOCALITIES

The geographic location of the localities under consideration is shown in Fig. 2. Rav W-1 occurs in an orange (weathering yellow), lithic, medium-grained channel sandstone exposed in a commercial clay quarry, 3.5 km WNW of the village of Ravenscrag, Saskatchewan. The sandstone grades upward into interbedded grey and buff clays and fine sands. Collections of Rav W-1 were originally made from a grassy slope adjacent to the worked face of the clay quarry. The fossiliferous horizon was no more than about 1/3 m thick and occurred in a clay-pebble channel lag deposit at the base of laterally discontinuous indurated sandstone masses. The productive layer extended laterally for about 10 m in a roughly SE-NW direction before visibly pinching out to the NW and being covered to the SE by grass and surficial gravels. The covered interval extended farther east about 5 m, and was in turn truncated by the wall of the clay quarry, which extended roughly perpendicular to the outcrop of the fossiliferous layer. It was later discovered that the Rav W-1 horizon extended onto the face of the quarry wall. Here the production layer was up to a meter thick. Fossils were recovered from the bases of indurated masses here as well. The indurated masses were present above and below the productive layer but fossils occurred in only a restricted interval.

Commercial clay operations destroyed the Rav W-1 layers but exposed the Long Fall lens at the base of the sandstone, directly below the original position of Rav W-1. The Long Fall lens is about 1/3 m thick, but is not known to extend laterally for more than about 2 m. The stratigraphic position of Rav W-1 and Long Fall, as well as the lithologic character of the unit, is shown in Fig. 3.

Figure 2. Geographic location of known Late Cretaceous and early Paleocene fossil-mammal localities of southwestern Saskatchewan.



Localities.

FR-1: Frenchman-1 (Late Cretaceous, Johnston 1980)
LF: Long Fall (Late Cretaceous)
R1: Rav W-1 (Puercan)
CP: Croc Pot
PC: Pine Cree (Puercan, Russell 1974)

Sections X

RB: Ravenscrag Butte (Furnival 1946; Russell 1951)
AB: Anxiety Butte (Kupsch 1956)

Figure 3. (a) Exposed section on quarry wall at the Rav W-1 locality as it appeared in August 1975. Two figures are standing at the level of the Rav W-1 fossil layer and provide an indication of scale. (b) Exposed section on quarry wall as it appeared in August 1979 after renewed commercial excavation. The figure is holding a meter stick for scale. Gross lithologies of the Ravenscrag Formation are indicated. Key to formations: Kw - Whitemud, Kb - Battle, Kf - Frenchman, K-Tr - Ravenscrag.

Rav W-1

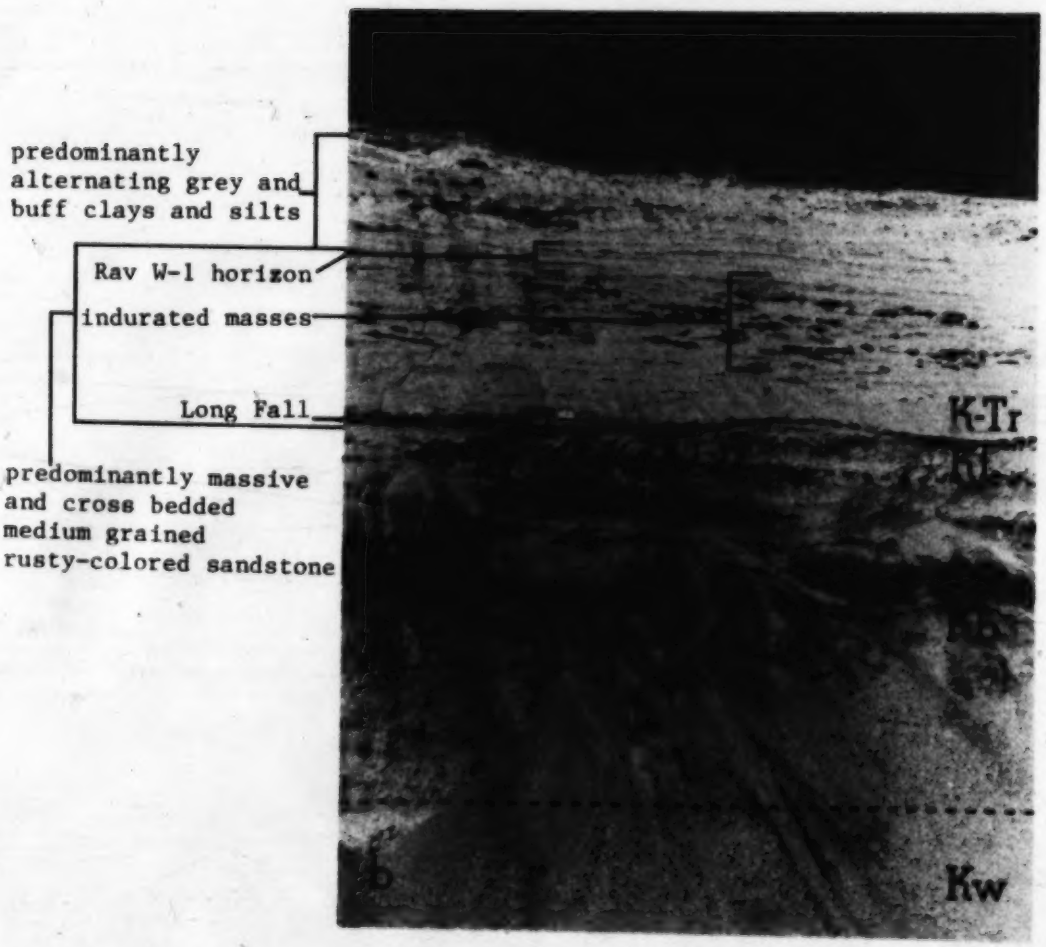
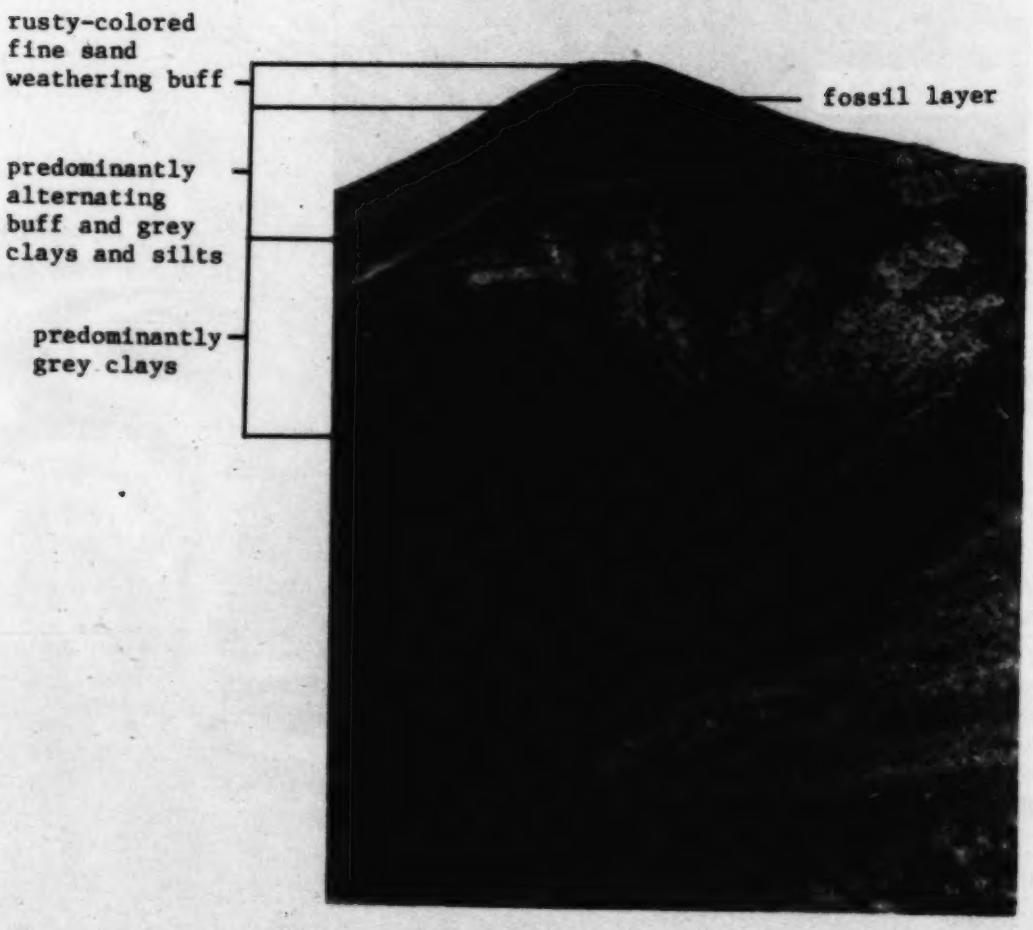

predominantly alternating grey and buff clays and silts
Rav W-1 horizon
indurated masses
Long Fall
predominantly massive and cross bedded medium grained rusty-colored sandstone
K-Tr
Kl
Kw

Figure 4. Croc Pot locality. A figure, standing near the center of the photograph just above the grey/buff transition, provides an indication of scale. Gross lithologic units are indicated.


rusty-colored
fine sand
weathering buff
predominantly
alternating
buff and grey
clays and silts
predominantly
grey clays
fossil layer

It is evident from Fig. 3b that only a very short measured interval (3.1 m) separates Long Fall from Rav W-1; there is no visible evidence of a disconformity or an abrupt lithologic change between the two horizons. The indurated masses, characteristic of the Rav W-1 horizon, first begin gradually, about a meter above the base of the sandstone, and become more concentrated for a short interval up section. Fig. 3a shows the position of Rav W-1 on the quarry wall as it appeared in August 1975. Rav W-1 occurred 3.4 m above the base of the sandstone within the zone of the indurated masses. Fig.3b shows the quarry wall as it appears now. The zone of indurated masses was largely destroyed by commercial excavation; that which remains is below the level of Rav W-1 although Rav W-1 was originally within that zone.

Dinosaur teeth (including one ceratopsian tooth and six teeth of small theropods, including cf. Saurornithoides sp. and ?Cheirostenotes sp. [M. Greenwald, 1980, pers. comm.], although rare, have been recovered from Long Fall; the marsupial, Pediomy elegans Marsh 1889 is also present (see p. 210 below), and is unknown from post-Cretaceous sediments. These fossils are well preserved and show no evidence of reworking (all the same color and the color of the Rav W-1 fossils; no rounding, etc.); they indicate the Long Fall horizon is of Late Cretaceous (Lancian) age (see p. 234 below for discussion).

Dinosaur teeth are absent from Rav W-1, as are teeth of P. elegans or any other marsupial. Other mammalian fossils at Rav W-1 indicate a Puercan age (see p. 234 for discussion).

Scales and disarticulated bones of the gar-pike Lepisosteus were exceedingly abundant at Rav W-1 and were the most common of vertebrate remains. Mammalian teeth were relatively rare, but underwater screening

during the last six years has resulted in the recovery of about 900 isolated teeth and tooth fragments, and five dentulous jaws (3 of condylarths and two of insectivores) bearing more than one tooth. About 50 isolated mammalian teeth have been recovered from Long Fall.

About 1.5 km SW of Rav W-1, along the same wall of the river valley, a second Paleocene site (designated "Croc Pot") was discovered during the last three days of the scheduled field season of 1979. Surface collecting yielded 21 isolated mammalian teeth, mostly of condylarths. Cursory examination of the condylarths from Croc Pot indicate that they differ taxonomically from those at Rav W-1, although some appear closely related. A P4 referable to the multituberculate genus Taeniolabis was recovered from Croc Pot and indicates the site is of Puercan age.

Vertebrate remains at Croc Pot are apparently weathering from a yellowish-orange sand (weathering buff) near the top of a hill. The hill is capped by Oligocene conglomerate of the overlying Cypress Hills Formation. The distribution of lithologies and position of the fossiliferous horizon at Croc Pot are shown in Fig. 4 . The upper part of the hill consists primarily of alternating grey and buff clays, although the overall weathering color is buff, while the lower part of the hill is predominately grey clay. These lithologies are characteristic of the Ravenscrag Formation. The base of the hill is covered with grass thereby obscuring the contact with the underlying Frenchman Formation.

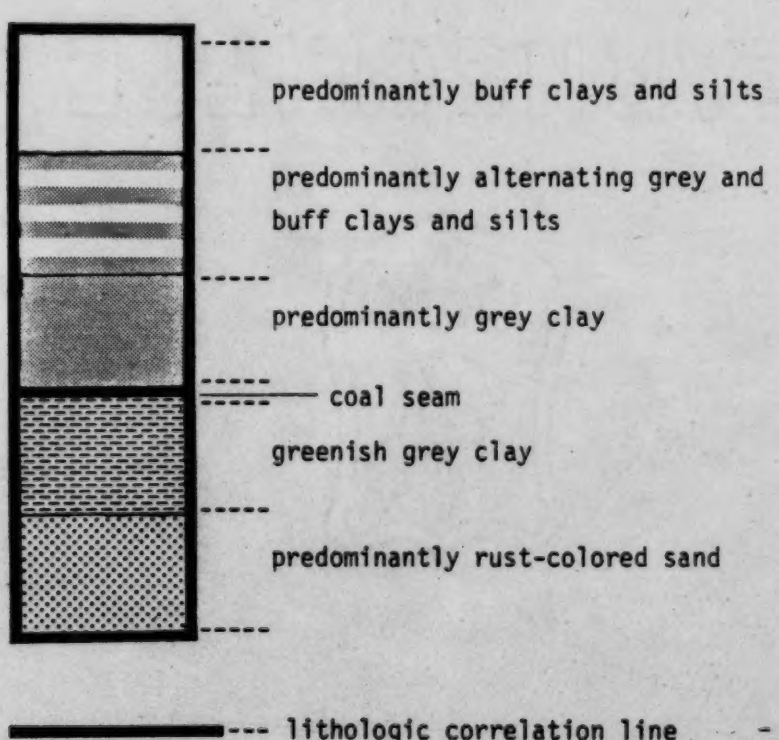
LOCAL CORRELATION

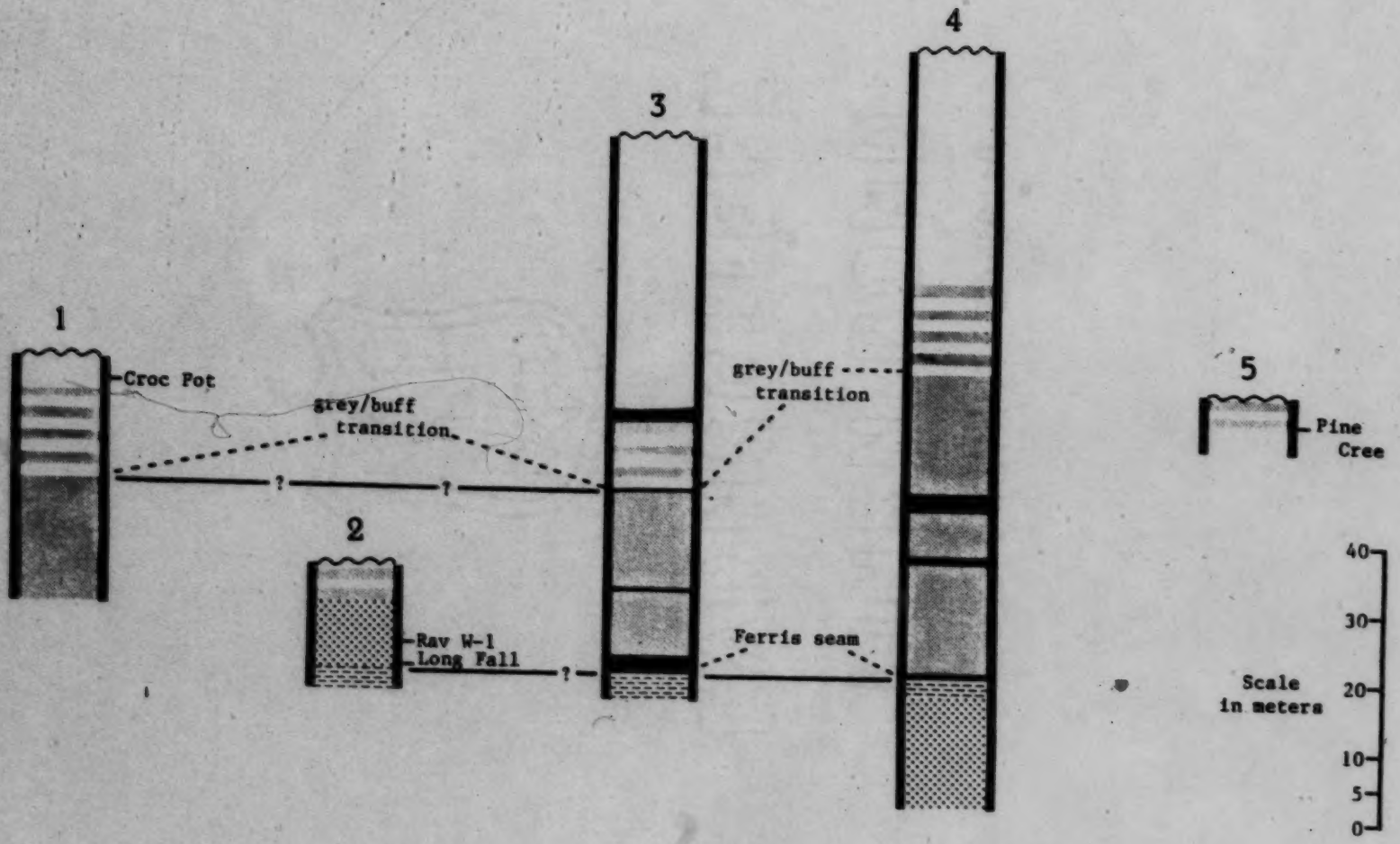
In the vicinity of Eastend and Ravenscrag, the lower boundary of the Ravenscrag Formation is placed at the base of the lowest commercial coal, the No. 1 or Ferris seam. Furnival (1946: 94) designated the beds lying between the post-Battle unconformity and the base of the Ferris seam, the Frenchman Formation. Vertebrate fossils (particularly dinosaur remains) of Lancian age are relatively common in the Frenchman Formation (Sternberg 1924; Kupsch 1956; Johnston 1980) but have not been reported from above the Ferris seam. Consequently the base of the Ferris seam is, in practice, taken to indicate the Cretaceous-Tertiary boundary, although some workers have pointed out that paleontological evidence is lacking to substantiate this conclusion (Russell 1951; Kupsch 1956).

The Ravenscrag Formation, including the Ferris seam, is well exposed at the type section at Ravenscrag Butte and at Anxiety Butte, several miles to the east. Both of these sections have been described in detail, the former by Furnival (1946) and Russell (1951), and the latter by Kupsch (1956). Lithologic correlation of the sections at Rav W-1 and Croc Pot with the section at Ravenscrag Butte has been attempted (see Fig. 5). Neither the Ferris seam nor other coal seams are present at Croc Pot or at Rav W-1. At the Rav W-1 section, lithologic changes above the base of the channel sand are entirely gradational, so that the only distinct lithologic boundary suitable for correlation is the top of the green clay that underlies the channel sandstone. This green clay closely resembles the greenish clay of the Frenchman Formation that directly underlies the Ferris seam at Ravenscrag Butte. On the basis of this comparison, I regard the

Figure 5. Correlation of sections exposed at (1) Croc Pot, (2) Rav W-1, (3) Ravenscrag Butte, (4) Anxiety Butte, and (5) Pine Cree. Croc Pot is about 1.5 km SW of Rav W-1; Ravenscrag Butte is about 9 km E of Rav W-1; Anxiety Butte is about 17 km NE of Ravenscrag Butte; and Pine Cree is about 4 km NE of Anxiety Butte. Illustration of the section at Ravenscrag Butte is based on description given by Furnival (1946: 108) and Russell (1951: 35-36); illustration of the section at Anxiety Butte is based on description by Kupsch (1956: 24-28).

Key for stratigraphic sections:




1
Croc Pot
grey/buff
transition
?
?
2
Rav W-1
Long Fall
?
3
grey/buff
transition
Ferris seam
4
5
Pine
Cree
Scale
in metera
40
30
20
10
5
0

green clay above the Battle Formation and below the channel sand at the Rav W-1 section as representing the clay phase of the Frenchman Formation, and the channel sand above the green clay as equivalent with the grey phase of the Ravenscrag Formation. The rust-colored channel sand at the Rav W-1 section is very different in appearance from the predominantly grey clays and silts of the grey phase at Ravenscrag Butte; this I interpret as facies difference, the former representing a channel fill deposit and the latter, primarily flood plain deposits. Rust-colored sand is not entirely foreign to the grey phase of the Ravenscrag formation; Russell (1974) reports some rust-colored concretionary sandstone in the grey phase at Ravenscrag Butte and buff to rusty-buff fine-grained sand at this level, east of the Ravenscrag Butte area, in the Morgan Creek Badlands southwest of Kildeer.

A fault occurs between Rav W-1 and Croc Pot, with Croc Pot on the downthrow block. Lithologic markers are absent at the Croc Pot section, except that the upper part of the section consists primarily of alternating grey and buff silts and clays, while the lower part is predominately grey clays. At Ravenscrag Butte and Anxiety Butte, alternating buff silts and grey clays occur in the lower part of the buff phase, according to descriptions given by Furnival (1946: 108), Russell (1951: 35-36) and Kupsch (1956: 24-28). These are indicated by alternating bands in Fig. 5 . Russell (1974) places the grey/buff transition at about the base of these alternating beds. Minor buff beds may also occur within the grey phase and grey beds within the buff phase, so that only predominant lithologies are shown in Fig. 5. For lack of other lithologic markers, I have estimated the pre-fault position of

Croc Pot relative to Ravenscrag Butte (Fig. 5) on the basis of the bottom of the alternating grey/buff beds. This leaves Croc Pot well within the buff phase of the Ravenscrag Formation. A distinct line of contact of the grey and buff facies is generally difficult to select at close range and is obvious only in large sections at a distance (pers. obs. and Russell 1951; Kupsch 1956). The sections at Croc Pot, Ravenscrag Butte and Anxiety Butte are extensive so that the grey/buff transition is reasonably distinct.

At Rav W-1 and Pine Cree, the sections exposed are not extensive. Both grey and buff beds are present in the upper part of these sections (although the weathering color is predominantly buff), and are shown as alternating bands in Fig. 5 . Owing to the short intervals exposed, it is not clear whether the lithology present at Pine Cree and the upper part of Rav W-1 corresponds to the grey phase, buff phase or grey/buff transition of the sections at Ravenscrag Butte and Anxiety Butte. By instrumentation Russell (1974: 8) concluded that the Pine Cree locality was equivalent to the grey phase of the Ravenscrag Formation at Anxiety Butte, but was near the grey/buff transition. Altitudinal measurements were not taken at Rav W-1; however, its position relative to underlying strata indicates it (and Long Fall) corresponds to the grey phase at Ravenscrag Butte. The buff beds at Pine Cree and at the top of the section at Rav W-1 may correspond to minor buff beds within the grey phase, and were more vertically extensive sections exposed at these localities, the overall lithology might well appear grey.

Pine Cree has yielded a single identifiable mammalian specimen, referable to Oxyprimus albertensis. The species occurs at Rav W-1,

as well, but was not represented among the few specimens recovered from Croc Pot; however, additional sampling of Croc Pot is necessary to determine whether O. albertensis is present there or not. Until the stratigraphic range of O. albertensis is better understood, it is of questionable value in correlating Rav W-1 and Pine Cree. Pine Cree is at about the same level as Croc Pot in Fig. 5 . This does not necessarily indicate temporal equivalence, as the restored stratigraphic position of Croc Pot is tentative. Furthermore, Russell (1974: fig. 1) has demonstrated that the grey phase thickens eastward from Ravenscrag Butte to Anxiety Butte and beyond. It may be that time lines diverge to the east, so that temporal correlation of Pine Cree with Croc Pot on stratigraphic position alone is ill-advised.

Considerable controversy occurred in the past as to whether the sandy phase and clay phase of the Frenchman Formation are time equivalent units (see Kupsch 1957: 417 for review of opposing views). Russell (1940, 1951, 1974) regarded sand units immediately underlying typical Ravenscrag strata, particularly in the area west of Ravenscrag Butte, as representing early Paleocene channel filling, and ascribed them to the Ravenscrag Formation. Furnival (1946) and Kupsch (1957), however, viewed these sands as belonging entirely to the Frenchman Formation, the latter on the basis of dinosaur remains collected from these sands at various localities.

The geographic and stratigraphic position, as well as the lithology of the channel sand at Rav W-1, indicates this unit is undoubtedly one of the controversial sandunits discussed above. The fossils recovered from Long Fall and Rav W-1 indicate that both Late Cretaceous and early Paleocene time is represented. I have included the channel sand at

Rav W-1 within the Ravenscrag Formation for reasons discussed above. According to this interpretation, the time interval represented by the Ravenscrag Formation should be extended to include part of Lancian time.

Many workers have viewed the Ravenscrag Formation of southwestern Saskatchewan as equivalent with much of the Fort Union series of Montana and North Dakota and thus representing most of Paleocene time (Russell 1932, Kupsch 1956, Byers 1969, Guliov 1972). This view, first enunciated by Russell (1932), is based largely on the lithologic resemblance of the buff facies of the Ravenscrag with the Tongue River Formation of North Dakota and Montana; the grey facies was viewed as equivalent with the Tullock and Lebo formations of Montana and Ludlow Formation of North Dakota (Russell 1950). The bulk of evidence derived from fossil mammal collections from the Tongue River Formation of North Dakota indicates a Tiffanian age (Late Paleocene) for that formation (Holtzman 1978: 16). The Tullock Formation of Montana is thought to encompass the Puercan (Sloan and Van Valen 1965) (and by necessity, the Mantuan, earliest Paleocene). The Lebo is of Torrejonian age (Simpson 1937).

The Croc Pot mammals occur in a lithology characteristic of the buff facies of the Ravenscrag, and if restored to the proper stratigraphic position shown in Fig. 5, they occur well up in the section relative to the type section at Ravenscrag Butte. The Croc Pot horizon appears to be of Puercan age on the basis of the presence of Taeniolabis sp. It seems inconceivable that the entire Torrejonian (estimated to be about three times the combined length of the Mantuan and Puercan [Sloan et al. 1979, unpubl.]) and part of the Tiffanian

is represented by the remaining beds of the buff facies above the level of Croc Pot (assuming sedimentation rates in the buff facies were comparable to that of the grey facies). Consequently, the upper part of the Ravenscrag Formation in the type area should be viewed as encompassing late Lancian to no more than about mid-Torrejonian time (mid-Lebo) at latest. E-log and palynological evidence (Whitaker 1978; Sweet 1978) are in accordance with this view and indicate strata of the Ravenscrag Formation equivalent to the Tongue River Formation occur no farther west than about Tp. 4, R. 27, W2 (southeast of Willowbunch) (op. cit.: pl. 2).

SYSTEMATICS

Systematic treatment of the mammalian taxa represented in the Rav W-1 and Long Fall assemblages is divided into two parts according to locality, beginning with Rav W-1 and followed by Long Fall. Of the mammalian specimens recovered from Rav W-1, only those referable to the Multituberculata, Primates and Condylarthra are described; those specimens referable to the Insectivora are omitted from the present study owing to inadequate samples and the poor state of early Paleocene insectivore taxonomy.

Description of first and second molars of neoplagiaulacids recovered from Rav W-1 is also omitted; these teeth overlap considerably in cusp formula and measurements and, in the absence of dentulous neoplagiaulacid jaws from Rav W-1, it was found to be an impossible task to confidently assign the molars to species. Frequency data utilized by some workers having large sample sizes (e.g. Krause 1977; Rigby 1980) were not helpful in the present study as the sample size from Rav W-1 was comparatively small (no more than ten p4's were recovered for any one species of neoplagiaulacids). Taxonomy of neoplagiaulacid multituberculates in the present paper is based entirely on isolated P4/p4's, which have generally proven to be diagnostic of neoplagiaulacid species (Jepsen 1940; Sloan 1980 [in press]).

All identifiable mammalian remains recovered from Long Fall are described; however, only a small volume of sediment from that locality has been processed thus far, so that the taxa described almost certainly do not represent the actual diversity of mammalian taxa in the Long Fall assemblage.

Part I: Rav W-1

Class Mammalia

Subclass Allotheria

Order Multituberculata

Suborder Ptilodontoidea

Family Ptilodontidae Gregory and Simpson 1926

Ptilodus Cope 1881

Ptilodus sp.

(Figure 6)

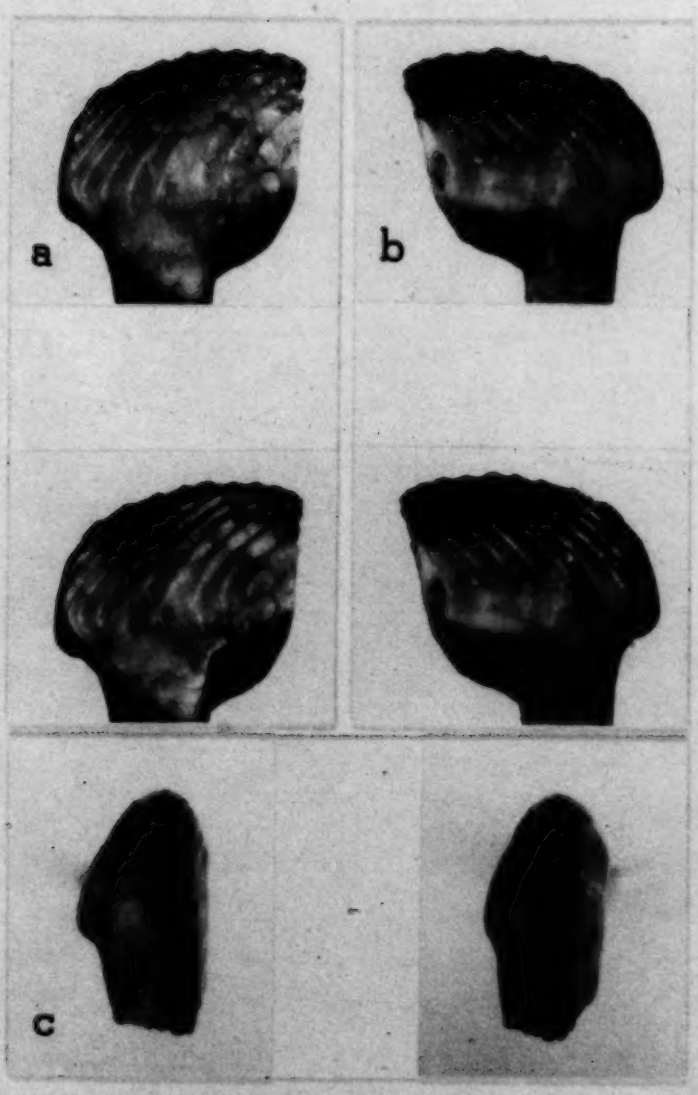
Referred specimens: UA 16164, p4.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan; Puercan, Nacimiento Formation, New Mexico; Puercan, Tullock Formation, Montana.

Discussion: A single fragmentary p4 recovered from Rav W-1 is indistinguishable from undescribed p4's recovered from Purgatory Hill, Tullock Formation, Montana. The Purgatory Hill specimens are referable to a new primitive species of Ptilodus(Sloan 1980, pers. comm.), which has been described on the basis of material from Tsosie Rincon, Nacimiento Formation, New Mexico (Sloan 1980 [in press]). p4, Ptilodus sp. is easily distinguished by its relatively large size and distinctive profile from that of any other multituberculate in the Rav W-1 assemblage.

Figure 6. Ptilodus sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 16164, left p4, width 2.00, about X9.


a
b
c

Family Neoplagiulacidae Ameghino 1890

Mesodma Jepsen 1940

Mesodma formosa (Marsh) 1889

(Figures 7, 8; Table 1)

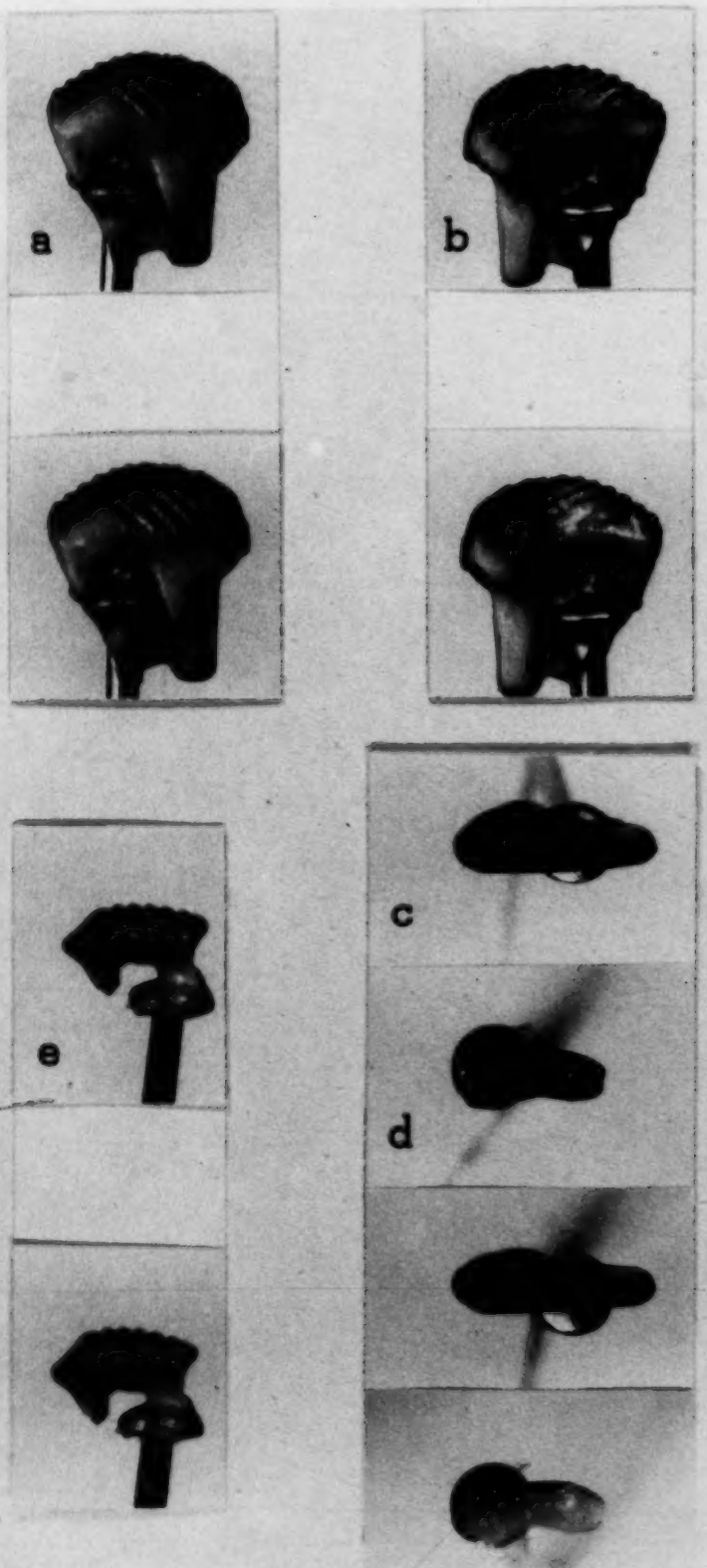
Referred specimens: UA 16185-93 (total:9), p4's; UA 16194-96 (total:3), P4's.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian, Lance Formation, Niobrara County, Wyoming; Lancian, Hell Creek Formation, Garfield and McCone counties, Montana; Puercan, Ravenscrag Formation, near village of Ravenscrag,Saskatchewan; Puercan, Tullock Formation, Montana; Puercan, Nacimiento Formation, San Juan County, New Mexico.

Discussion: The referred specimens are qualitatively and quantitatively indistinguishable from corresponding specimens referred to Mesodma formosa from the Scollard Formation of Alberta (Lillegraven 1969) and from the Lance Formation of Wyoming (Clemens 1963). M. Formosa has been described in detail (ibid.) so that redescription here is unnecessary. Fig. 8 shows the range of variation of profiles of p4 in the present sample.

Figure 7. Mesodma formosa, Rav W-1: (a) labial (b) lingual, and (c) occlusal view, UA 16185, right p4, length 3.40, about X9; (d) occlusal, and (e) labial view, UA 16194, left P4, Length 2.45, about X9.


a
b
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d
e

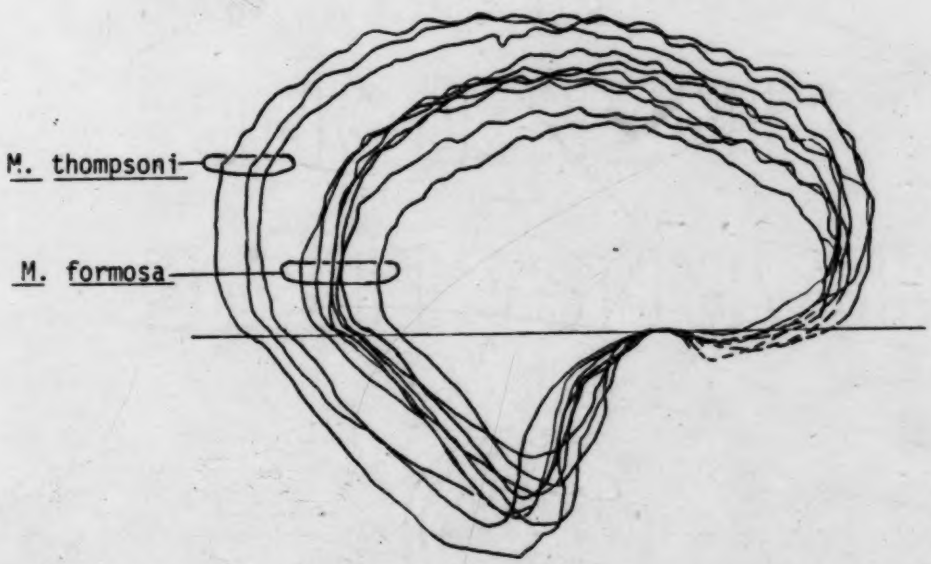


Figure 8. Superimposed camera lucida outlines of labial surface of p4's referred to Mesodma formosa and Mesodma thompsoni, Rav W-1: profiles oriented using highest point of enamel between roots and datum line through this point and top of anterobasal concavity; labial view, X30.

Table 1. Measurements of the dentition of Mesodma formosa, Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	7	2.80-3.45	3.18
	L1	6	1.25-1.55	1.43
	h	5	1.35-1.85	1.63
P4	L	3	2.20-2.45	2.30
	W	3	.85- .95	.93

Mesodma thompsoni Clemens 1963

(Figure 9; Table 2)

Referred specimens: UA 16076-78 (total: 3), p4's, UA 16098, P4.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distributions: Edmontonian, St. Mary River Formation, Scabby Butte, Alberta; Lancian, Scollard Formation, near Trochu, Alberta; Lancian, Hell Creek Formation, Garfield and McCone counties, Montana; Lancian, Lance Formation, Niobrara County, Wyoming; Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan; Puercan, Nacimiento Formation, Tsosie Rincon, New Mexico.

Discussion: Distinction of certain species of Mesodma, such as M. thompsoni and M. formosa, is fundamentally a statistical problem (Novacek and Clemens 1977). The small sample from Rav W-1 does not lend itself to such an exercise. Superimposed profiles of p4's referable to Mesodma indicate that there is a considerable range of variation of size as well a suggestion of bimodality in the sample although the latter may be owing to sampling bias. The larger group is referred to M. thompsoni as qualitative differences do not exist with specimens of that species from Bug Creek Anthills.

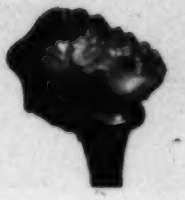
Novacek and Clemens (1977) demonstrated that the sample of Mesodma from Bug Creek Anthills varied statistically from M. thompsoni in the Lance local fauna but they suggested this may be only of subspecific significance. The Rav W-1 p4's are apparently most similar to p4's in the Bug Creek Anthills sample, particularly in the relative height of the blade which, on the basis of Novacek and Clemens' (1977: 704) data, is slightly larger than in the Lance sample. The single P4 referred here agrees in

Figure 9. Mesodma thompsoni, Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 16076, left p4, length 4.1, about X9; (d) occlusal, and (e) labial view, UA 16098, left P4, length 2.7, about X9.

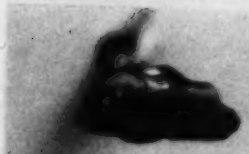
a

b

c



e



d

Table 2. Measurements of the dentition of Mesodma thompsoni, Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	3	3.65-4.00	3.93
	Ll	2	1.60-2.15	1.88
	h	2	1.90-2.15	2.03
P4	L	1	2.70	----
	W	1	2.40	----

all particulars with P4's in the Bug Creek Anthills sample referable to *Mesodma*.

Ectypodus Matthew and Granger 1921

Ectypodus sp.

(Figure 10; Table 3)

Referred specimens: UA 16099-16100, p4's.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: p4--Two p4's recovered from Rav W-1 appear to represent a species of Ectypodus. p4 is about the size of p4, Mesodma formosa, although more arcuate and with a higher crown as indicated by its relatively higher h/L ratio (=.56) (h/L p4, M. formosa =.46, on basis of Lance Lull 2 sample, Novacek and Clemens 1977:704). The serrate crest is damaged anteriorly on UA 16099 and is worn posteriorly on UA 16100; a serration count of twelve is estimated for both specimens. The height of the first serration on UA 16100 is 1.35; about 40 per cent the standard length. The labial height of the crown from the base of the exodaenodont lobe to the apical crest is less than the standard length.

The profile of p4, E. sp., is similar to that of Ectypodus powelli Jepsen 1940 (Tiffanian, Polecat Bench Formation, Wyoming); however, p4, E. sp., is more arcuate anteriorly and bears more serrations.

Discussion: The p4's referred here agree in all respects with a revised diagnosis of the genus Ectypodus (Sloan 1980 [in press]). It is likely that a new species is represented by the Rav W-1 sample; however, adequate diagnosis awaits the recovery of additional material. The Rav W-1 species documents the earliest known species of the genus,

Figure 10. Ectypodus sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 16100, left p4, length 3.25, about X9.

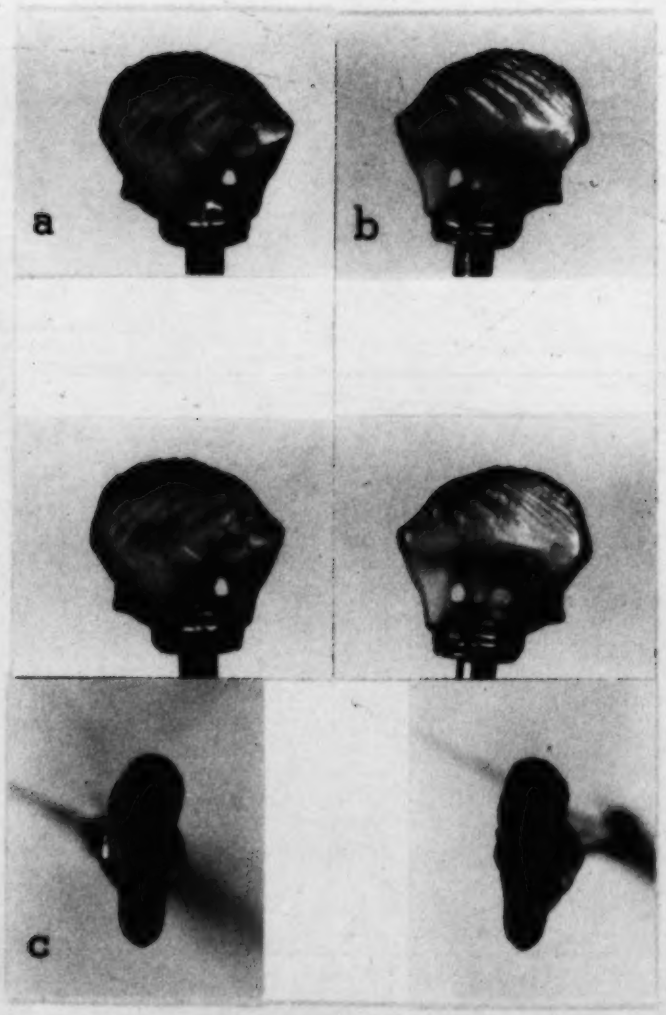

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Table 3. Measurements of the dentition of Ectypodus sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	2	3.00-3.25	3.13
	Ll	2	1.40-1.50	1.45
	h	2	1.70-1.80	1.75

which is otherwise known only from post-Puercan strata.

Neoplagiaulax Lemoine 1882

Neoplagiaulax kremnus n. sp.

(Figures 11, 12; Table 4)

Etymology: κρημνός, Gk., crag; reference is to the village of Ravenscrag, Saskatchewan, near which the known specimens of this species were discovered.

Type specimen: UA 15142, isolated left p4.

Type locality: NW. 1/4, sect. 23, Tp. 6, R. 24, W. 6; Loc. Rav W-1, about 3.5 km. WNW. of the village of Ravenscrag, Saskatchewan.

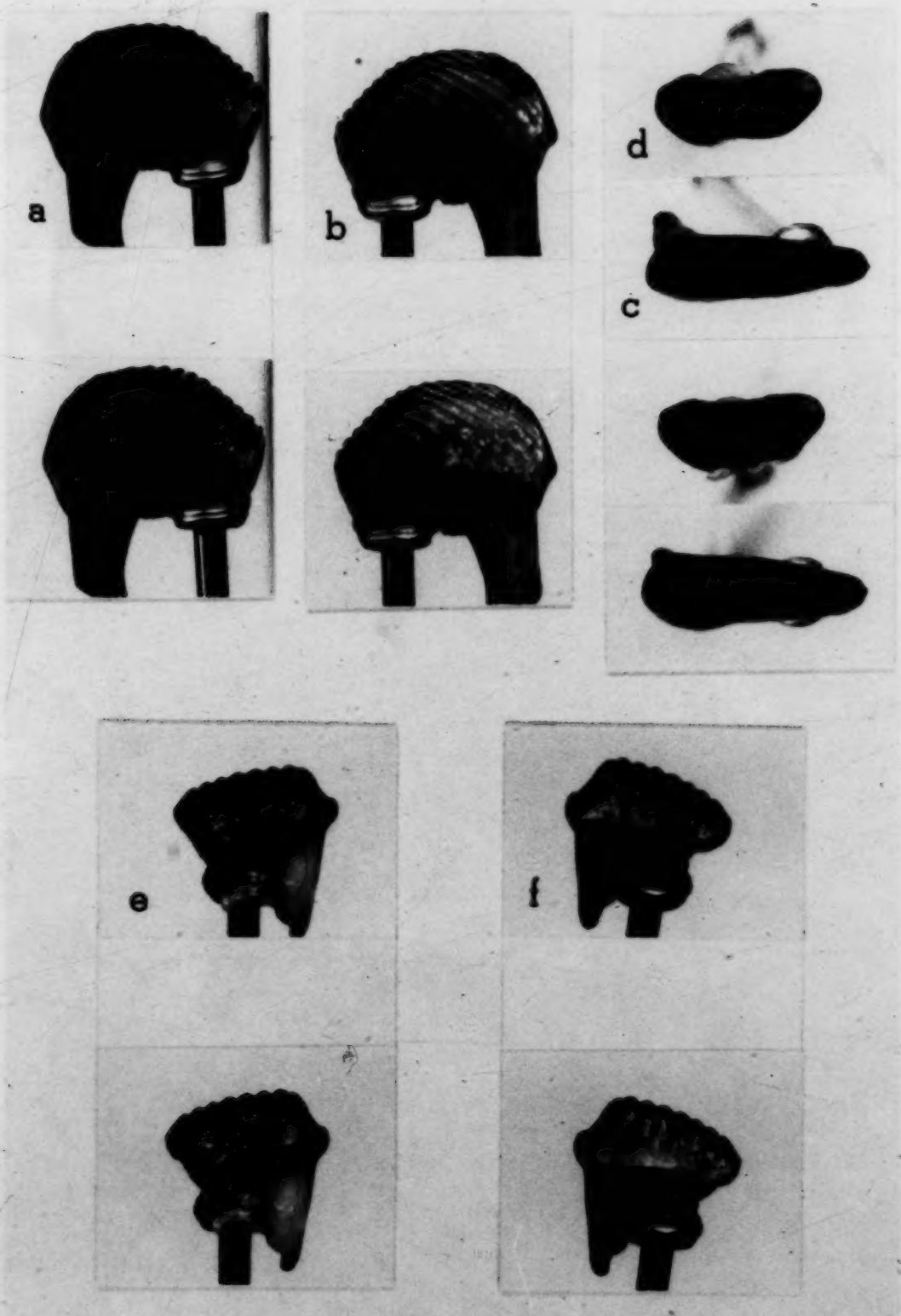
Referred specimens: UA 15143-15150 (total: 8), p4's; UA 15118, 15151-15156 (total: 7), P4's.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: p4 very similar to that of both Neoplagiaulax hunteri (Simpson) 1936 and Neoplagiaulax cf. N. hunteri (Swain Quarry) but differing in that the anterior face of the crown is relatively broader and flatter and crenulations above the posteroexternal shelf less well developed; modal serration number one fewer than in N. hunteri. P4 not as high crowned as P4, N. hunteri and N. cf. N. hunteri, modally bearing two fewer medial cusps and invariably with external cusp.

Description: p4. -- p4, Neoplagiaulax kremnus, is in most features, particularly the lateral profile, very similar to that of N. hunteri (Simpson) 1936 (Scarritt Quarry, Roche Percee) and N. cf. N. hunteri (Swain Quarry). As in these species the crown is essentially trapezoidal with the anterior portion of the apical crest straightened or slightly convex and roughly parallel with the lingual base of the crown. The

Figure 11. Neoplagiaulax kremnus n. sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 15142 (type), left p4, length 4.40, about X9; (d) occlusal, (e) labial, and (f) lingual view, UA 15118, right P4, length 3.2, about X9.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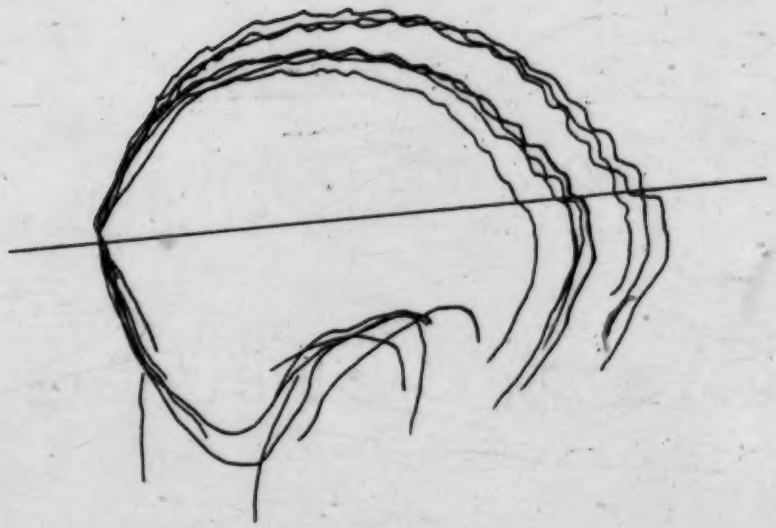

Figure 12. Superimposed camera lucida outlines of p4's referred to Neoplagiaulax kremnus n. sp., Rav W-1: profiles oriented using top of anterobasal concavity and datum line through this point and most posterior interserrational notch; labial view X20.

Table 4. Measurements of the dentition of Neoplagiaulax kremnus n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	7	4.10-5.15	4.65
	L1	7	2.00-2.80	2.29
	h	5	2.35-2.60	2.46
P4	L	6	3.00-3.30	3.14
	Ant-W	6	1.20-1.40	1.32
	Post-W	5	1.20-1.50	1.38

height of the first serration is as follows: N=9, OR=1.65-2.15, M=1.96. There is a considerable range of variation in size as evident in Fig.12; the observed range of length of p4 exceeds at both extremes that of p4, N. hunteri, from Scarritt Quarry (Melville Formation, Simpson 1936), Roche Percee (Ravenscrag Formation, Krause 1977) and Brisbane (Tongue River Formation, Holtzman 1978). The largest specimens likewise exceed the largest of N. cf. N. hunteri (Swain Quarry, Rigby 1980), but the smallest specimens are not as small as the smallest of the latter sample. The serration number (12-14) is modally 14, matching that of N. cf. N. hunteri and one fewer than in N. hunteri.

On the basis of size and lateral profile alone, p4's of N. kremnus are indistinguishable from those of N. cf. N. hunteri and N. hunteri; however, several other subtle but consistent morphological differences distinguish the p4 of this species: the anterior face of the crown is distinctly broader and flatter; that portion of the anterior face defined by the ventrally extending branches of the bifurcated median ridge is directed more anteriorly and less anterolingually than in N. cf. N. hunteri and N. hunteri; posteriorly, the crenulations above the posteroexternal shelf are less well developed.

P4. -- Cusp formula, 1:7-8 (mode 1:7). The cusp comprising the external row is invariably positioned beneath or slightly anterior to the apex of the second most anterior cusp of the internal row; in two specimens, the external cusp is preceded by a minute cuspule. The posterior slope of the profile is steep and slightly concave; the anterior slope is gently convex with the apogee at the ultimate cusp. Below the anteriormost point on the crown, the enamel retreats posteroventrally toward the base of the anterior root, forming an

overhanging ledge with a slightly concave, anterobasally facing lower surface. A lobe is developed below the cusp of the external cusp row that extends posterobasally onto the labial flank of the leading root; the anterior margin of the lobe is oriented anterodorsally and is confluent with the labial edge of the anterior overhanging shelf; the posterior margin is parallel with the posterior margin of the leading root. Lingually the base of the enamel bulges slightly ventrally over the trailing root and to a lesser extent over the leading root. The roots are subequal and converge distally. Size variation is not as great as in p4 and there is no indication of bimodality. Unlike P4, N. hunteri and N. cf. N. hunteri, P4, N. kremnus is not as high crowned, modally bears two fewer medial cusps and invariably rather than occasionally bears a cusp (and sometimes a cuspule as well) in the external cusp row.

Discussion: At the onset of this study the p4's referred here to N. kremnus were thought to represent two species owing to the relatively wide range of variation of length and the apparent bimodality of the sample (see Fig. 12). P4's showed no evident bimodality. The sample, however, of p4 (and P4) is too small to eliminate the possibility of sampling bias as an explanation of the distribution of variation in Fig. 12. The degree of variation of length of p4, N. kremnus exceeds that known for N. hunteri and N. cf. N. hunteri but is not excessive compared to some other ptilodontoids, such as Ptilodus mediaevus Cope 1881 in the Swain Quarry (see Rigby 1980: 50). Therefore, the sample of p4's under consideration here is, for the present, viewed as representing a single species, N. kremnus, with the recognition that additional specimens may reveal N. kremnus to be a composite species.

All of the p4's referred to N. kremnus differ in the same ways from those of both N. hunteri and N. cf. N. hunteri; that is, that the anterior face of the crown is broader and flatter and that the crenulations above the posteroexternal shelf are less well developed; these character states, as well those noted above for P4, are primitive relative to those in N. hunteri and N. cf. N. hunteri assuming that, among known ptilodontoids, Mesodma formosa or Mesodma thompsoni most closely approach the ancestral state of the Neoplagiaulax lineage (see Van Valen and Sloan 1966: Fig. 5; Sloan 1980 [in press]).

Parectypodus Jepsen 1930

Paraectypodus armstrongi n. sp.

(Figures 13, 14; Table 5)

Etymology: After Buster T. Armstrong on whose land the Rav W-1 locality occurs and who generously allowed us access over the past several years.

Type specimen: UA 15117, Lp4.

Referred specimens: UA 16079-87 (total: 9), p4's; UA 16088-93 (total: 6), P4's.

Type locality: NW 1/4, sect. 23, Tp. 6, R. 24, W. 6, Loc. Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: p4 larger than in Parectypodus vanvaleni Sloan 1980 (in press) and Parectypodus clemensi (ibid.) or any other known species of Paractypodus other than Parectypodus trovessartianus (Cope) 1882a, which is much larger. P4 with more cusps in the medial row than in P. vanvaleni and P. clemensi.

Description: p4. -- 12 to 14 (mode: 12) serrations are on the apical crest. Height of first serration is as follows: N=9, OR=1.9-2.1, M= 2.0. The profile is high and arcuate with the apogee occurring at the third or fourth serration at a point anterior to the midpoint of the length of the crown. The apical crest rises in a gentle arc from the front of the crown to the apogee and then descends in nearly a straight or slightly concave line posteriorly. The profile appears asymmetrical with the greatest mass (apart from the exaenodont lobe) concentrated

Figure 13. Parectypodus armstrongi, Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 15117 (type), left p4, length 4.40, about X9; (d) labial view showing accessory external cusp, UA 16092, left P4, length 4.35, about X9; (e) occlusal, (f) labial, and (g) lingual, UA 15118, left P4, length 4.15, about X9.

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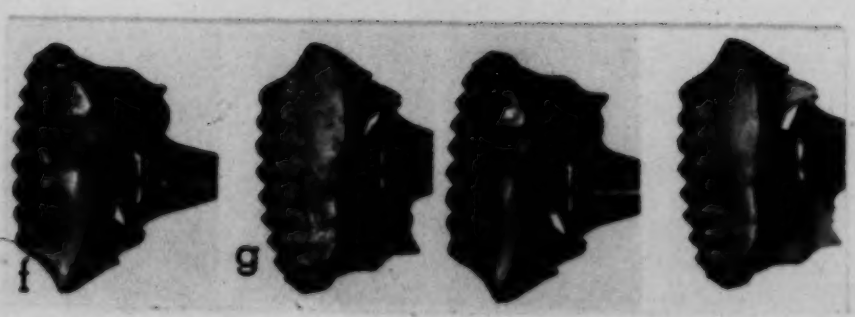
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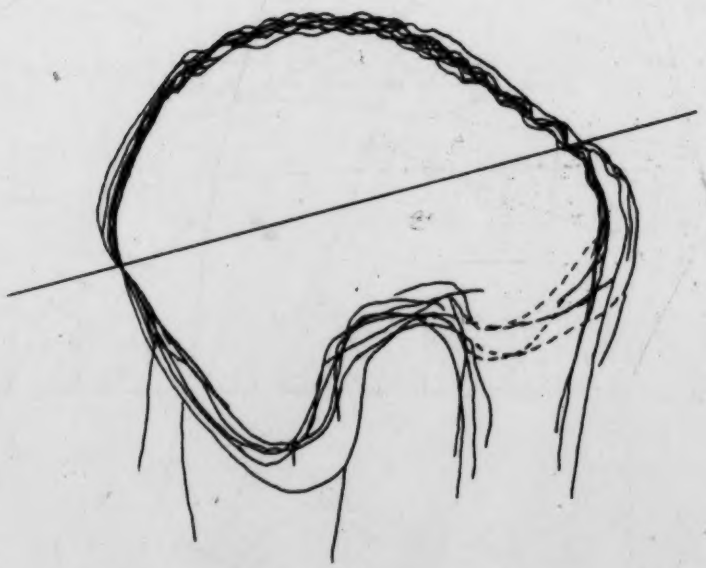


Figure 14. Superimposed camera lucida outlines of p4's referred to Parectypodus armstrongi n. sp., Rav W-1: profiles oriented using top of anterobasal concavity and datum line through this point and most posterior interserrational notch; labial view, X20.

Table 5. Measurements of the dentition of Parectypodus armstrongi n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	9	4.55-4.95	4.71
	Ll	9	1.90-2.45	2.17
	h	9	2.50-2.90	2.60
P4	L	5	4.10-4.35	4.24
	W	6	1.60-1.80	1.72

in the anterior half, rather than being equally distributed fore and aft. A labial and a lingual ridge arise from the first serration, although the latter usually extends ventrally for a greater distance (up to a third the distance to the roof of the anterobasal concavity) and is almost always more pronounced. The first labial and first lingual ridge are inclined more steeply than are successive ridges. In addition to the lateral ridges, a short median ridge usually descends anteroventrally from the first serration. The enamel of this ridge may be raised to form a variably developed incipient serration. The median ridge of the first serration generally descends farther ventrally than does the first labial ridge, but not as far as the first lingual ridge before it fades into the face of the crown. The second labial ridge usually truncates the first while the second lingual ridge converges with and is often truncated by the first lingual ridge; if not truncated, this ridge generally bends at its ventral extent toward the third ridge. Successive ridges bend downward in their ventral descent and are parallel in their orientation. Ridges fail to arise lingually from the ultimate and often the penultimate serrations. The labial ridges of the last three cusps are progressively disrupted posteriorly by variably developed, posteroventrally directed crenulations. A vestige of the original anteroventrally directed ridges is visible descending from the penultimate and in one specimen (UA 16080) from the ultimate serration. The crenulations may branch or anastomose at various points along their length and are truncated posteriorly roughly perpendicularly by the posterolabial shelf. The posterolabial shelf descends the crown anteroventrally at an angle like, or slightly less than, that of the labial ridges, to a point below the first (occasionally) or second

(usually) serration. In many specimens the labial grooves between the last two or three serrations curve posteroventrally following the trend of the crenulations. Lingually, ridges usually fail to arise from the ultimate and penultimate serrations and if present, are often disrupted by lingual crenulations; these crenulations are much weaker than the labial crenulations, show no consistent orientation, and are present only in some specimens (3 of 9). The anterobasal concavity is well developed and generally gives rise to a ventrally descending groove on the anterior face of the leading root, indicating the existence of p3 in this species. The base of the crown bears a bulge lingually above the anterior root that may (2 specimens) protrude below the level of the base of the enamel immediately posterior to it. Posteriorly, the base of the crown generally dips down onto the lingual flank of the posterior root. The anterior root is compressed anterolabially - posterolingually and extends anteroventrally from the base of the crown. The posterior root is shorter, more cylindrical and less robust than the anterior root and curves slightly anteriorly. A relatively weak interradicularcrest runs between the roots with a ventrally directed prominence about mid-way along.

P4. -- Cusp formula: 3-5:9-10. In two specimens (UA 16092-93) a small cusp occurs labial to the external row below the third or fourth external cusp at the point of greatest labial protrusion of the crown (see Fig.13d). The first two or three medial cusps are smaller than more posterior cusps. In lateral view the anterior slope forms a long, low, gentle arc with the apogee at the penultimate serration; the posterior slope is steep and concave. Labially, the base of the crown is straight or gently concave.

Discussion: Two species of Parectypodus other than P. armstrongi are known from the Puercan: an undescribed species from Purgatory Hill, Tullock Formation, Montana (Van Valen and Sloan 1966) that is similar to and perhaps conspecific with Parectypodus clemensi (Sloan 1980 pers. comm.) and Parectypodus vanvaleni, Tsosie Rincon, Nacimiento Formation, New Mexico. P. armstrongi is more primitive in some characters of the known dentition than is P. vanvaleni but less so in others. The relative height of the first serration (height 1st serration/length p4 = .47) of p4, P. armstrongi, is primitively lower than in P. vanvaleni (.55, ibid.) but both p4 and P4 are more cuspidate, a derived condition. The lateral profiles of p4, P. armstrongi and P. vanvaleni, are quite different; the anterior face of the former is shorter, more rounded and more steeply inclined and the apogee is more anteriorly placed relative to crown length. Neither P. armstrongi nor P. vanvaleni appear derivable from one another although Sloan (ibid.) has suggested that the latter is a plausible ancestor of all other members of the genus. Archibald (1977) described a single Parectypodus-like p4 from the Hell Creek Formation (Late Cretaceous), Montana, that in lateral profile and serration number (12) is very similar to p4, P. armstrongi, more so than is p4, P. vanvaleni. The p4 of the Torrejonian species P. clemensi is also similarly shaped to p4, P. armstrongi, but is much smaller; P4, P. clemensi, bears fewer cusps in the medial row.

The occurrence of a cusp labial to the external cusp row on some P4's referable to P. armstrongi is, to my knowledge, unique among neoplagiaulacids. The presence of cusps labial to the external row is characteristic of most ptilodontids, including Ptilodus and Kimbetohia. Unlike known ptilodontids, however, the external cusps of P4, P. armstrongi

are much lower on the crown than are the medial cusps. P4, P. armstrongi, is high and arcuate and the first serration is relatively high on the apical crest indicating that affinities lie with species of Parectypodus rather than with any known ptilodontid.

Parectypodus sp.

(Figure 15; Table 6)

Referred specimens: UA 15119, p4; UA 16183, P4.

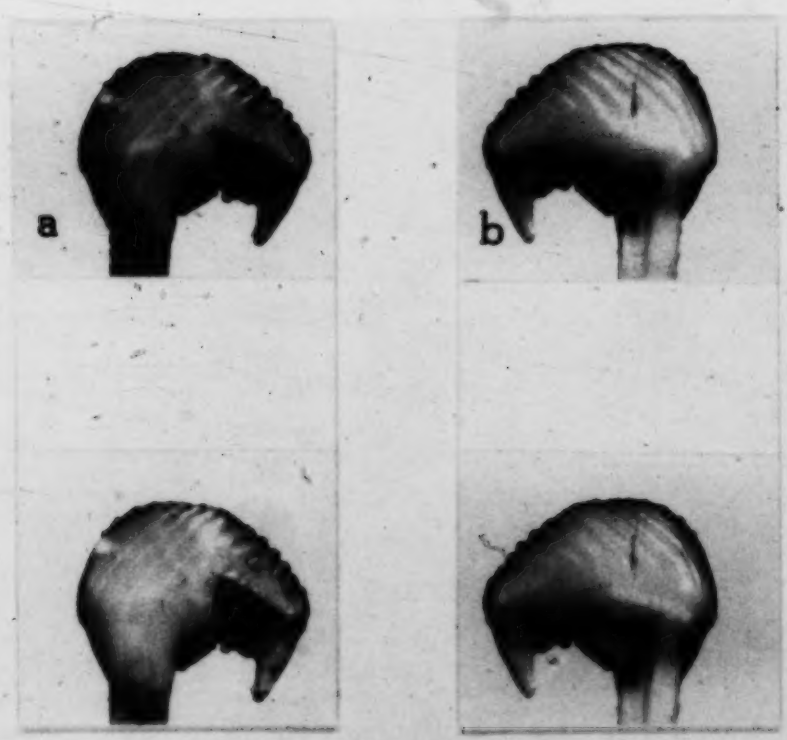
Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag Saskatchewan.

Description: p4 -- A single p4 has been recovered from Rav W-1, that represents a smaller species of Parectypodus than P. armstrongi. The apical crest bears fourteen serrations, plus one anterior incipient serration. The third, fourth and fifth serrations are slightly chipped; however, judging by the curvature of the apical crest, the apogee appears to have been at the fourth serration. The height of the first serration is 1.90. Lingually, ridges arise from all but the last three serrations; labially, ridges, if any, that may have arisen from posterior serrations have been obscured by a large wear facet. The labial ridge arising from the eighth serration extends the farthest ventrally. A median ridge descends anteroventrally from the serration, bears an incipient serration and then bifurcates before fading into the face of the crown. The anterobasal concavity is well developed from which a groove extends down the anterior edge of the leading root. Posteriorly, the lateral expressions of the last three interserration valleys recurve posteroventrally. The posterolabial shelf is very weak and consists of nothing more than a weak ridge descending from the ultimate serration and curving anteriorly for a short distance.

Although p4, P. sp., is known from only a single specimen (UA

Figure 15. Parectypodus sp., Rav W-1: (a) labial, and (b) lingual view, UA 15119, left p4, length 3.90, about X9; (c) labial, (d) lingual, and (e) occlusal view, UA 16183, left P4, length 3.65, about X9.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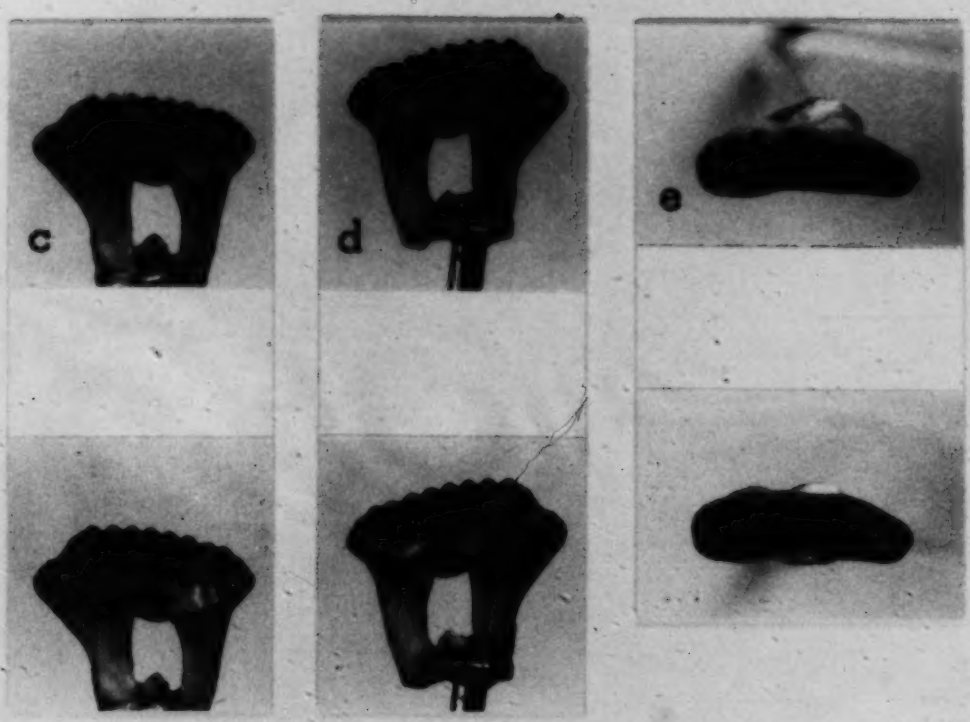
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Table 6. Measurements of the dentition of Parectypodus sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	1	3.90	----
	L1	1	1.50	----
	h	1	2.20	----
P4	L	1	3.60	----
	W	1	1.30	----

15119), it is readily distinguished from that other species of Parectypodus. The serration count of UA 15119 is greater than the modal value of other species of Parectypodus (generally 10-12) but does not exceed the range of variation of certain of these species (e.g. specimens of both P. trovessartianus and P. laytoni bear up to fourteen serrations (Granger and Simpson 1929: 631 and Jepsen 1940: 297 respectively). p4, Parectypodus vanvaleni (Sloan 1980, in press), from Tsosie Rincon (Puercan, Nacimiento Formation), is of comparable size to that of P. sp. but bears fewer serrations, a relatively higher first serration and a differently shaped anterior face. The lateral profile of p4 is similar to that of p4, Parectypodus laytoni (Jepsen) 1940 (Tiffanian, Polecat Bench Formation), but is much larger and the posterior slope is more gently inclined.

P4 -- A single P4 (UA 16183) is referred to this species (cusp formula, 4:10). The form of this tooth is very similar to p4, P. armstrongi, except that the crown is distinctly smaller and relatively higher; the anterior half of the crown is relatively narrower; and the base of the enamel, in lingual view, is emarginated ventrally between the roots. The profile is similar to that of p4, P. laytoni; however, in occlusal view, the anteroexternal bulge protrudes labially much farther than in that species.

Discussion: The high arcuate profile of p4, P. sp., and the relatively high placement of the first serration indicates the generic identity of this species is with species of Parectypodus. It is likely that a new species is represented by this sample; however, diagnosis is deferred until additional specimens are acquired and some concept of variability in this species is gained.

Suborder ?Ptilodontoidea

Family ?Neoplagiaulacidae

Xyronomys Rigby 1980

Xyronomys sp.

(Figure 16; Table 7)

Referred specimens: UA 15115-16, 16018-20 (total: 5), p4's.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: p4 -- 12 to 13 serrations comprise the serrated crest with the apogee at the fifth serration. The profile is distinctly low, long and gently convex and is easily distinguished from that of any other multituberculate in the Rav W-1 assemblage. The crown is relatively thin labiolingually with delicate serrations and the roots are gracile. The exodaenodont lobe is weakly developed and in labial view bears a slightly concave, shallowly inclined leading edge (less so in UA 16019). Labially, that portion of the base of the crown between the roots is relatively longer, straighter and more nearly horizontal than in eucosmodontids and other ptilodontoids. The posterolabial shelf is weakly developed and does not extend anteriorly beyond a point below the antepenultimate serration. The rear of the crown bulges posteriorly slightly beyond the trailing edge of the posterior root. A distinct longitudinal groove is present on the leading edge of the anterior root below the well formed anterobasal concavity; p3 was evidently present in this species. Anterolingually, the base of the crown is swollen, forming a small lobe that bulges lingually as far as the exodaenodont lobe bulges labially. Lingual ridges descending

Figure 16. Xyronomys sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 15116, left p4, length 3.00, about X9.

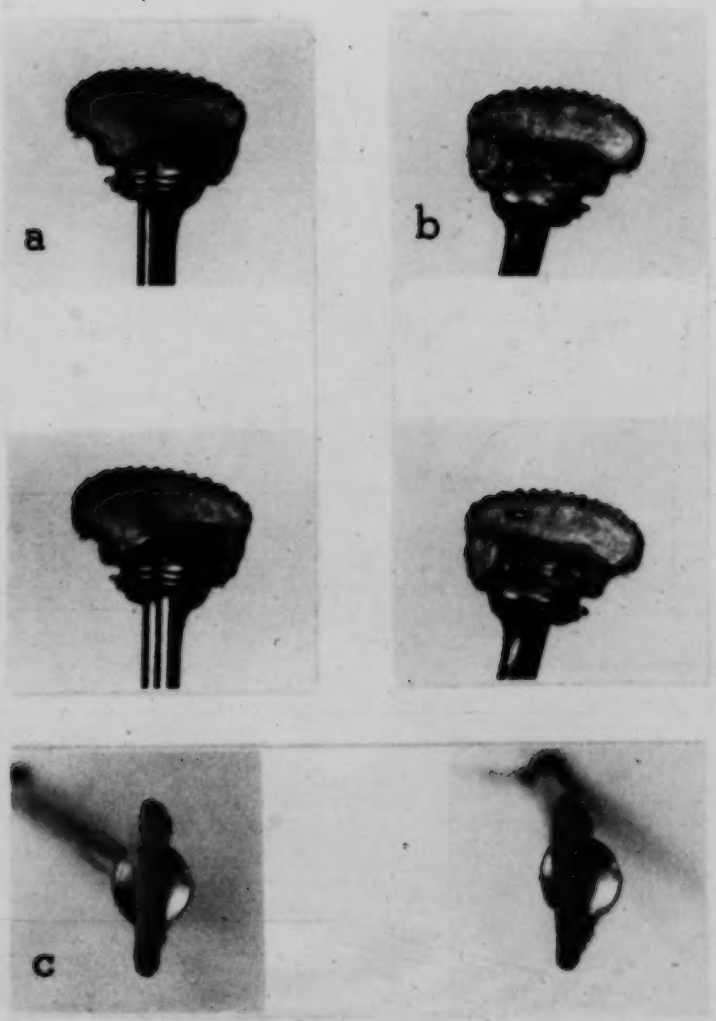
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Table 7. Measurements of the dentition of Xyronomys sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	3	2.95-3.00	2.98
	L_1	1	1.15	----
	h	1	1.30	----

from serrations along the anterior three-quarters of the serrated crest terminate ventrally at points horizontally in line with the midpoint of the anterior face of the crown between the roof of the anterobasal concavity and the first serration; labially, ridges descending from these serrations terminate in line with the roof of the anterobasal concavity; the three or four anteriormost ridges on both sides, however, terminate at points progressively more dorsal, anteriorly. The ventral extent of the posterior three or four serrations is obscured owing to wear and dissolution of the enamel in those specimens preserving that region of the tooth; it is difficult to tell whether the ultimate cusp gave rise to any ridges at all. A medial ridge descends anteroventrally from the first serration and occasionally bears a variably developed incipient serration. The first labial ridge is more steeply inclined than are subsequent ridges, truncates the short second ridge and may meet the third ridge at its ventral extent. Subsequent ridges are less steeply inclined than the first and become more widely spaced posteriorly. The first lingual ridge is short and very faint and appears to anastomose with the second ridge. The last three or four serrations become slightly more bulbous posteriorly. The interradicular crest is deepest midway along its length. The posterior root curves anteriorly.

Discussion: Apart from the Rav W-1 species, Xyronomys is represented elsewhere by the type species Xyronomys swaini Rigby 1980 in the Swain Quarry (Torrejonian, Fort Union Formation, Wyoming) and by an undescribed species in the Garbani Quarry (Puercan, Tullock Formation, Montana), (W.A. Clemens in progress). Rigby referred Xyronomys to the Eucosmodontidae on the basis of the relatively low profile of p4 that resembles that of certain eucosmodontids of the Rock Bench local fauna (Torrejonian,

Polecat Bench Formation, Wyoming). Rigby noted that elements of X. swaini were exceedingly rare and totalled only four specimens, all p4's, of the 28,000 mammalian specimens collected from Swain Quarry. It is probable that other elements of the dentition were present in the sample but were indistinguishable from those of some small neoplagiaulacids (there are no other known eucosmodontids in the Swain Quarry assemblage). Likewise, with Xyronomys sp., only p4's have as yet been recognized in the collections from Rav W-1. Unlike X. swaini, p4's of X. sp. are as or more abundant than p4's of many other multituberculate species at Rav W-1 such as, Stygimys n. sp., Microcosmodon n. sp., Taeniolabis sp., Ptilodus sp., Mesodma thompsoni, Parectypodus sp. and Ectypodus sp. It is probable that, as in the case of Swain Quarry, other elements of the dentition are present in the Rav W-1 sample but have not been recognized owing to the lack of associated material and possible similarity with other species. The unknown elements of the dentition of X. sp. could not be confused with any other eucosmodontid at Rav W-1 except possibly M. arcuatus, but here, elements of at least the lower dentition of this form are so distinctive that close similarity with X. sp. is unlikely. It seems more probable that the unknown elements of X. sp. are like those of some small neoplagiaulacid such as Mesodma. Such evidence is, in isolation, tenuous but, when considered in conjunction with that from Swain Quarry, suggests that Xyronomys may be a neoplagiaulacid rather than a eucosmodontid. I see no difficulty in deriving Xyronomys from Mesodma formosa or Mesodma hensleighi, both of which exhibit a relatively low profile of p4 as compared to other neoplagiaulacids. Sloan (1971, unpubl.) likewise indicates derivation of Xyronomys from

Mesodma formosa though provides no specific reasons in support.

p4, X. sp., is very similar to p4, X. swaini, in both size and structure and bears no noteworthy differences except that the crest has 12 to 13 serrations whereas that of X. swaini has 11. X. sp. likely represents a new species; however, there is as yet insufficient information about this form to provide an adequate diagnosis.

Suborder Taeniolabidoidea

Family Eucosmodontidae (Jepsen) 1940

Subfamily Eucosmodontinae Holtzman and Wolberg 1977

Stygimys Sloan and Van Valen 1965

Stygimys camptorhiza n. sp.

(Figures 17, 18, 19; Table 8)

Etymology: κάμπτω, Gk., bent & ῥίζα, Gk., root; reference is to the anteroventrally curving leading root of p4.

Type specimen: UA 15134, Lp4.

Type locality: NW 1/4, sect. 23, Tp. 6, R. 24, W. 6; Loc. Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 15135, 16003-16006 (total: 5), i1's; UA 16007-8, p4's; UA 15133, 16009-10 (total: 3), m2's; UA 15137-38, 16011-14 (total: 6), P4's; UA 15136, M1.

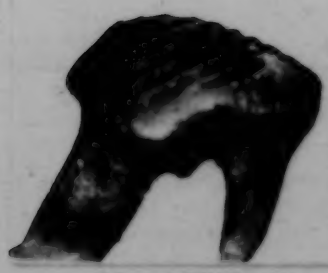
Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: Known elements of the dentition most similar to corresponding elements in Stygimys kuszmauli Sloan and Van Valen 1965 but smaller than or falling at the small end of the range of variation of size in that species (two P4's questionably referred to S. camptorhiza are an exception to this observation and are discussed below); anterior surface of the crown of p4 relatively narrower and labiolingually more convex, lateral ridges arising from serrations posterior to the apogee more steeply inclined and extending farther ventrally on exodaenodont lobe, anterior root extending from the crown at a more gentle angle than in S. kuszmauli; labial cusps of m2, particularly ultimate and penultimate cusps, not as distinctly separated as in S. kuszmauli.

Figure 17. Stygimys camptorhiza n. sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 15134 (type), left p4, length 4.30, about X9; (d) left, labial and right, lingual view, UA 16004, left i1, maximum diameter 3.10, about X5; (e) occlusal view, UA 15136, right M1, width 2.00, about X9; (f) occlusal view, UA 15133, left m2, length 2.20, about X9.

a

b

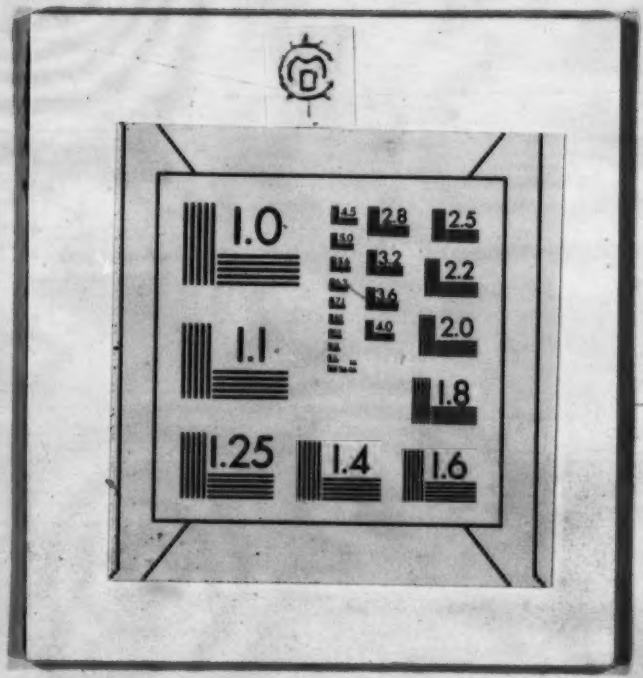


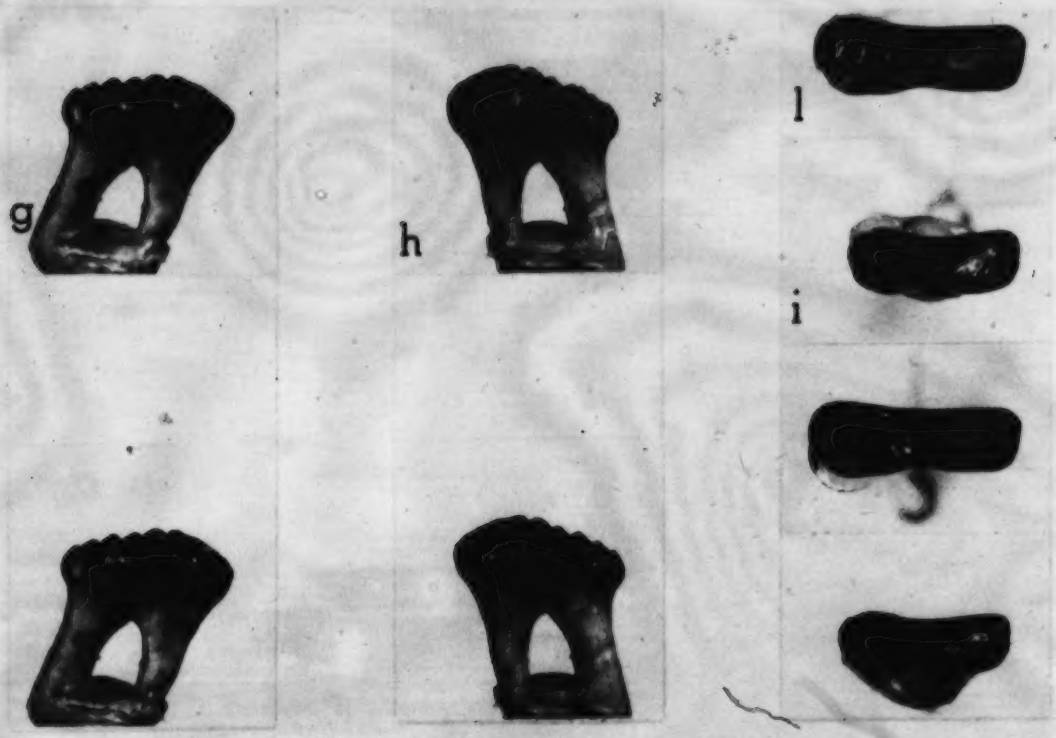
c d

e f

Figure 18. Stygimys camptorhiza n. sp., (g) labial, (h) lingual, and (i) occlusal view, UA 15138, right P4, length 2.85, about X9; ?S. camptorhiza, (j) labial, (k) lingual, and (l) occlusal view, UA 15137, right P4, length 3.5, about X9.

2




g
h
l
i

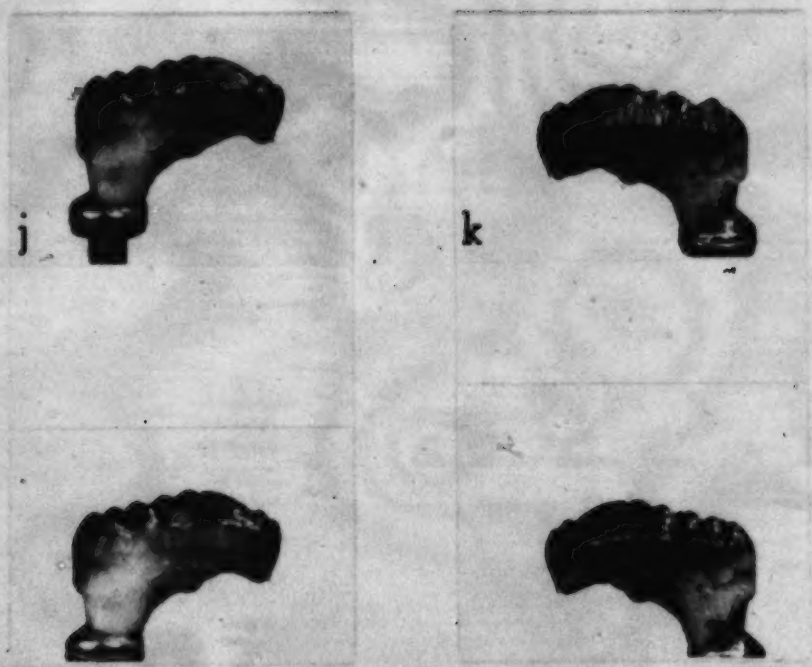
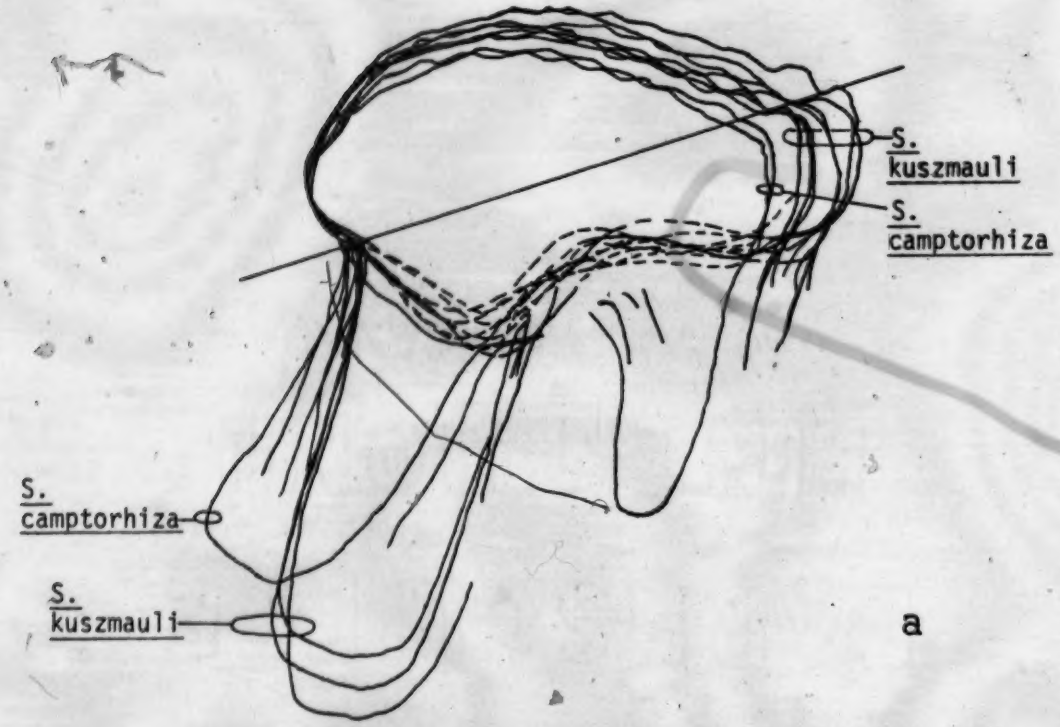

j
k

Figure 19. Superimposed camera lucida outlines of p4's referrable to Stygimys camptorhiza n. sp., Rav W-1 and Stygimys kuszmauli, Bug Creek Anthills: labial view, X20, (a) Profiles oriented using anterior margin of crown and datum line through intersection of leading margin of anterior root with crown and posteriormost interserrational notch, (b) profiles oriented using anterior margin of crown and with leading edges of anterior roots roughly parallel.


S. kuszmauli
S. camptorhiza
S. camptorhiza
S. kuszmauli
a

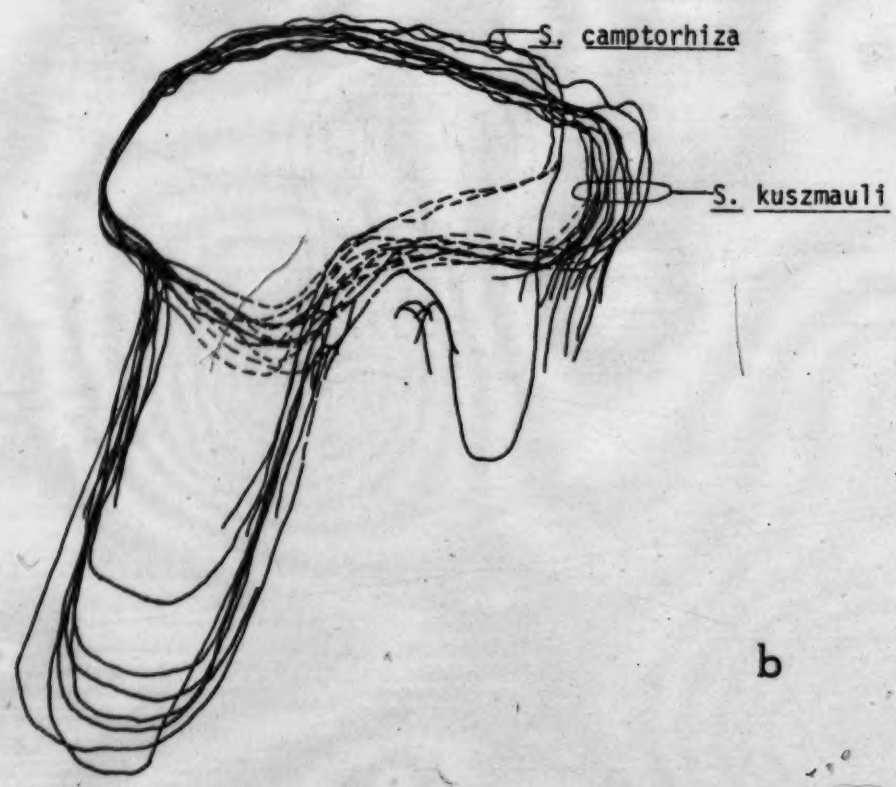

S. camptorhiza
S. kuszmauli
b

Table 8. Measurements of the dentition of Stygimys camptorhiza n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
i1	Max-D	4	2.90-3.15	3.03
	Min-D	5	1.30-1.50	1.40
p4	L	2	4.20-4.30	4.25
	L1	2	1.60-1.70	1.65
	h	2	1.90-2.05	1.98
m2	L	3	2.20-2.30	2.27
	W	3	1.60-1.70	1.65
P4	L	3	2.85-3.50	3.25
	W	4	1.10-1.35	1.23
M1	L	-	----	----
	W	1	2.00	----

Description: In addition to S. camptorhiza, four known species comprise the genus Stygimys: the type species Stygimys kuszmauli (Lancian, Hell Creek Formation, Montana), Stygimys gratus (Jepsen) 1930 (Lancian, Hell Creek Formation, Montana[1]; Mantuan, Polecat Bench Formation, Wyoming), Stygimys teilhardi (Granger and Simpson) 1929 (Torrejonian, Nacimiento Formation, New Mexico) and Stygimys jepseni (Simpson) 1935a (Torrejonian, Lebo Formation, Montana). An additional, unamed species, larger than S. kuszmauli, may be present in the Hell Creek Formation (Archibald 1977). The known parts of the dentition of S. camptorhiza are most similar to those of S. kuszmauli.

il. -- The lower incisors referable to S. camptorhiza closely resemble UA 16007, a lower incisor referable to S. kuszmauli, but are slightly smaller in diameter (UA 16007 has a maximum diameter of 3.65 and a minimum diameter of 1.7; max./min. = 2.15.). In neither of the Rav W-1 specimens is the anterior or posterior end preserved. The crown is uniformly curved and laterally compressed, with enamel restricted to the anteroinferior surface in typical eucosmodontine fashion. Judging from the tapering of the root end, the enamel terminated about midway along the length, as in S. kuszmauli. The enamel extends dorsally over approximately one-quarter of the medial surface and a little more than

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1) Archibald (1977: 142) suggested that specimens from the Harbicht Hill locality, Hell Creek Formation, McCone County, Montana, referred to S. gratus (Sloan and Van Valen 1965) may actually represent a new species that is possibly conspecific with specimens from UCMP locality V74111, Hell Creek Formation, Garfield County, Montana. If this proves true, S. gratus would be limited to the Mantuan Lentil of the Polecat Bench Formation, Wyoming, in its known distribution.

one-third of the lateral surface. The medial surface is flattened, and a groove in the enamel runs near to, and parallel with the inferior border almost to the posterior extent of the enamel. The ratio of maximum to minimum diameters (2.12) is less than in S. gratus (2.49, Jepsen 1940: 280), S. jepseni (2.86, Simpson 1937: 103) and much less than in S. teilhardi (3.25, Granger and Simpson 1929: 651). The relatively less compressed condition of the lower incisor in S. kuszmauli and S. camptorhiza is interpreted as a primitive character state for the genus.

p4. -- Three p4's referable to S. camptorhiza were recovered from the Rav W-1 locality, although only two, UA 15134 and 16007, are complete, and the enamel of the latter is dissolved away ventrally. Features evident in these specimens and characteristic of the genus Stygimys include a low, J-shaped profile and an anteriorly curving leading root. Specimens of p4, S. camptorhiza, are significantly smaller than p4, S. teilhardi and S. gratus, but are like p4, S. jepseni, in size. Morphologically, however, there are sufficient differences to warrant distinction of these two forms at the specific level. In S. camptorhiza the anterior half of the crown is relatively higher than in S. jepseni[2], the anterior face straighter and steeper, and the base of the crown overhanging the anterior root, less blunt. Posterolabially, the base of the crown extends straight back from the exodaenodont lobe, whereas in S. jepseni, the base of the crown dips

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2) The first two serrations of USNM 9769 (the type specimen and only known p4 of S. jepseni) are damaged but it is evident that the crown was never as high as in S. camptorhiza.

ventrally and flanks the upper part of the posterior root. The most striking difference is in the relative massiveness of the exodaenodont lobe, which in S. camptorhiza, extends farther ventrally and bulges far more labially than in S. jepseni. Finally, the anterior root in S. jepseni is slightly bowed anteriorly along its leading edge whereas the leading edge of the anterior root in S. camptorhiza is distinctly concave anteriorly.

Morphological similarities with p4, S. kuszmauli, are even more pronounced than with p4, S. jepseni, although the length of p4 in S. camptorhiza is less than for all but the smallest specimens of S. kuszmauli. Fourteen specimens of p4, S. kuszmauli, BCA, in the UA collection were found to have a mean length of 4.69 (OR = 4.35 - 5.10, SE = .06, SD = .21, CV = 4.55), all of them exceeding in length the p4's known for S. camptorhiza. Sloan and Van Valen (1965), however, found the mean length of p4, S. kuszmauli, in their sample to be 4.6 with a standard deviation of .3. Although they did not provide the observed range of their sample, the smallest specimens must necessarily have been as small or smaller than the p4's known for S. camptorhiza. Archibald (1977) provided statistics for a sample of 27 p4's, S. kuszmauli, in the UCMP BCA collection (M = 4.68, SD = .308, CV = 6.58, Archibald 1977: 141) that correspond closely to those of S. kuszmauli in the UA collection. Superimposed camera lucida outlines (Fig.19a) of p4, S. camptorhiza, and p4, S. kuszmauli, in the UA collection, indicate that, apart from a slightly straighter anterior face, the profile of p4, S. camptorhiza, though smaller in all dimensions, is essentially the same as that of p4, S. kuszmauli. When enlarged to a similar size, the profiles of the teeth are virtually indistinguishable.

In addition to its generally smaller size, p4, S. camptorhiza, bears certain subtle but consistent morphological differences that readily distinguish it from p4, S. kuszmauli. When viewed from above, the anterior face of the crown is relatively narrower than in S. kuszmauli and appears distinctly convex rather than flattened; in lateral view, the ridges arising from serrations posterior to the apogee are less steeply inclined, are relatively slightly closer together, and in the vicinity of the exodaenodont lobe, extend farther ventrally than in S. kuszmauli; the anterior root departs from the crown at a more gentle angle (see Fig.19a). When camera lucida outlines of p4, S. camptorhiza, and p4, S. kuszmauli, are superimposed so that the anterior edge of the leading root is roughly parallel, the posterior end of p4, S. camptorhiza, is tilted well above that of S. kuszmauli (see Fig.19b). This suggests p4, S. camptorhiza, was oriented in the jaw differently than in S. kuszmauli and likely occluded with P4 in a different manner. There are ten serrations in UA 15134 (the only specimen with a complete apical crest), one less than is reported for S. gratus (Jepsen 1940), S. jepseni (Simpson 1935a) and S. kuszmauli (Sloan and Van Valen 1965). This difference in serration number should not at present be considered a reliable taxonomic character, however, as serration counts are available for only two p4's of S. gratus (Jepsen 1940) and one of S. jepseni (Simpson 1935a, 1937). It is highly unlikely that the total variation of serration number of the original populations is represented by these samples or in the sample of p4's referrable to S. camptorhiza. Furthermore, the most posterior serrations in the type and only specimen of S. jepseni become progressively fused, thereby making a precise serration count exceedingly difficult; accordingly, Simpson's (1935a,

1937) count of 11 should best be viewed as an estimate. Sloan and Van Valen (1965) state that 11 serrations are diagnostic of p4, S. kuszmauli; however, there are three p4's (UA 16015-17) of this species from BCA in the UA collection bearing ten serrations. In view of the present sample size of all species other than S. kuszmauli (Sloan and Van Valen 1965 reported that 15 specimens referable to S. gratus (but see Archibald 1977: 142) were recovered from the Harbicht Hill locality in the Hell Creek Formation, Montana, but they did not describe these, nor indicate how many of these were p4's, nor provide serration numbers for the p4's) serration number cannot as yet be considered a useful character distinguishing any of the species of Stygimys from one another.

In UA 16007 an accessory ridge arises from a point one-third of the way down the height of the crown between the labial ridges originating from the fifth and sixth serrations; lingually the ridge originating from the fifth serration bifurcates mid-way along its length. There are no accessory or bifurcating ridges on the other two specimens. The anterior edge of the crown overhangs the root beneath, but no anterobasal concavity is present there, nor is there a groove along the front edge of the leading root. Evidently, p3 in this species had been lost, as is the case in other members of this genus (Sloan and Van Valen 1965).

On the labial surface, the sixth or seventh ridge is longest ventrally and the second or third ridge is the shortest. Both labially and lingually the first ridge is inclined more steeply than the other ridges. The serrations become slightly larger and inflated posteriorly, although not to the degree as in S. kuszmauli. A worn bulge occurs on the posterolabial shelf, where may have stood a small cuspule, as in

S. kuszmauli and S. gratus. The interradicular crest is contiguous with the anterior root and varies in shape (convex in UA 16008; coming to a ventral prominence in UA 15134).

m2. -- The m2's referred to S. camptorhiza are slightly smaller than the smallest m2's of S. kuszmauli in the UA collection though similar in form, proportion, and cusp ratio (4:2). (For length of m2's, S. kuszmauli (BCA), in the UA collection, N = 15, OR = 2.4 - 3.3 $\pm$ .23 SD, M = 2.66; width, N = 17, OR = 1.75 - 2.2 $\pm$ .12 SD, $\bar{X}$ = 1.93.) The only evident morphological difference from m2, S. kuszmauli, is that the cusps of the labial row in S. camptorhiza are not as distinctly separated, particularly the ultimate and penultimate cusps; these are adnate and crest-like in form and would be indistinguishable from each other except for a remnant of the intercusp valley marking the boundary of these cusps on the lingual slope. The remaining cusps are rounded and relatively massive. The anteriormost cusp of the lingual row is the highest and most massive of all of the cusps. One or two small cuspules occur on the crest extending posteriorly from the ultimate cusp of the lingual row, a condition variably expressed in S. kuszmauli. In occlusal view the labial margin of the tooth is straight or slightly concave and the lingual margin is convex. Wear occurs first and is most pronounced along the occlusal edge of the crest forming the posterolabial margin of the crown from the ultimate labial cusp to the anteroposterior valley of the tooth, whereas in S. kuszmauli, wear usually occurs first and is most pronounced along the crest extending posteriorly from the ultimate lingual cusp. The anterior surface of the leading root and the posterior face of the posterior root face obliquely labiolingually, roughly parallel with

the anterior and posterior edges of the crown, respectively.

P4. -- Two size morphs appear to be represented in the group of P4's referred here to S. camptorhiza; upon more extensive sampling, these morphs may prove to represent distinct species. Specimens comprising the larger morph (UA 15137 and 16011) are virtually indistinguishable from large p4's of S. kuszmauli, except that in the former the posterior end is generally, although not invariably, narrower. Had the specimens comprising the larger morph been found at the Bug Creek Anthills locality in the Hell Creek Formation of Montana, they almost certainly would have been referred to S. kuszmauli.

UA 15138, 16012-14 comprise the smaller morph. In addition to their smaller size, these teeth exhibit subtle morphological differences from the larger specimens: the vertical crenulations of the enamel extend farther ventrally, the anterior slope of the profile is slightly steeper and there are no small cusps developed posterior to the apogee on the descending slope of the median cusp row. In all of these features the smaller specimens are less like P4, S. kuszmauli, than are the larger ones. In occlusal view specimens of both morphs are hourglass-shaped with the constriction occurring midway along the crown. Crenulation of the enamel occurs on the lingual surface and variably on the labial surface of the median cusps anterior to the apogee and variably on the external cusps. Crenulations on the larger specimens are more evident than on most specimens of S. kuszmauli; however, water wear on many of the BCA specimens may enhance or entirely account for this. The crenulations in UA 15138, the only complete specimen in the smaller morph, are more pronounced and extensive than on any of the 21 P4's of S. kuszmauli in the UA collection.

The cusp ratio of the larger specimens(2-3:8:0-?1) falls within the range of variation expressed in P4, S. kuszmauli (2-3:7-10:0-1), whereas the smaller teeth (2-3:6:0-?1) exhibit fewer cusps in the medial row than do P4's of S. kuszmauli at hand, owing to the lack of cusps posterior to the apogee in the Ravenscrag specimens. The cusps of the medial row in both morphs are individually low (apex to base of intercusp valley) and of subequal size other than the most anterior cusp, which can be smaller. Cusps of the external row increase in size posteriorly; when two cusps comprise the row, the first cusp is the most labially positioned, and when three, the second cusp is the most labial. The cusps of the median row posterior to the apogee tend to fuse into a crest as in S. kuszmauli and become indistinguishable; one or two small cusps follow the crest posteriorly except in specimens of the small morph and even on them, a slight bulge occurs on the descending slope of the crest or posterior to it that likely represents the vestige of a cusp. Wear patterns on UA 15137-38, 16011 indicate that a cusp was possibly present posterolingually in the internal row, as in many specimens of P4, S. kuszmauli.

Size difference alone is insufficient to warrant the referral of either morph to a species other than S. camptorhiza as the variation in size approaches but does not exceed that in S. kuszmauli. The 21 P4's (BCA) referable to S. kuszmauli in the UA collection exhibit a range of 3.10-3.80 in length (M = 3.38 $\pm$ .20 SD) and a range of 1.10-1.40 in width (M = 1.27 $\pm$ .10 SD). The significance of the apparent morphological differences between the two morphs is more difficult to assess. P4 has not been described for S. jepseni, S. gratus or S. teilhardi, and its range of morphological and dimensional variation in

these forms is consequently not available for comparison. In S. kuszmauli some small specimens can have a slightly steeper anterior slope than large specimens but there is no evident difference in the degree of crenulation of the enamel nor of the development of cusps posterior to the apogee. Specimens in the larger morph from Rav W-1 actually exceed the mean length of P4, S. kuszmauli, but are not as large as the largest P4's of that species. If the known p4's referrable to S. camptorhiza represent the average size of teeth at this position for this species, then specimens of the large morph alone are larger than would be expected if the P4/p4 ratio is like that for S. kuszmauli and are actually closer to the size expected for S. gratus. The P4/p4 ratio for S. kuszmauli in the UA collection is 3.38/4.69 = .72. If the p4's referred to S. camptorhiza represent an average length for this species, then the average length of P4 is expected to be about 3.1 by extrapolation from S. kuszmauli. P4 length in S. gratus is expected to be about 3.5, if the two p4's described represent an average size for that species. Specimens of the smaller morph are closer to the expected length for S. camptorhiza. Nevertheless, owing to the present small sample size, only the acquisition of additional P4's will reveal whether a true bimodality exists. Consequently, UA 15137 and 16011 are tentatively referred to S. camptorhiza.

M1. -- A single fragmentary M1 is referred to S. camptorhiza. The portion of the tooth anterior to the middle of the fourth cusp of the median row is broken away. The width of UA 15136 falls well below that in S. gratus (M1, 2.6, Jepsen 1940: 280) and slightly below the smallest M1's of S. kuszmauli in the UA collection (OR = 2.2-2.55, M = 2.3 for 15 specimens). As in M1, S. kuszmauli, the cusps are deflected

anteriorly and are relatively massive (more so than in any other multituberculate M1's in the Rav W-1 assemblage other than in Taeniolabis sp.), and the ultimate cusp of the median row is more rounded, massive and set off posteriorly than are more anterior cusps of that row and the other rows. Four cusps comprise the internal row; the most anterior cusp is small and crest-like and may actually represent the fusion of two cusps. Apart from size, M1, S. camptorhiza, is distinguished from M1, S. kuszmauli, by only a few differences: the presence of a thin ridge, about half the height of the medial cusps, extending across each intercusp valley of the medial cusp row, uniting the cusp bases (this feature is absent or only incipiently developed in S. kuszmauli); and the penultimate cusp of the medial cusp row is relatively less massive than in S. kuszmauli.

Discussion: Except for the two relatively large P4's (UA 15137, 16011) described above, all specimens referred to S. camptorhiza are consistently smaller than or fall at the small end of the range of variation of corresponding teeth in S. kuszmauli, thereby corroborating their association in the new species, S. camptorhiza. The two questionably referred P4's (UA 15137, 16011) may prove to pertain to S. gratus. S. gratus is known elsewhere from the Harbicht Hill locality (Lancian) in the Hell Creek Formation, Montana (Sloan and Van Valen 1965), and from the Mantua Lentil (Mantuan) of the Polecat Bench Formation, Wyoming (Jepsen 1940); therefore, it would not be surprising if S. gratus were eventually demonstrated to occur in the Rav W-1 local fauna, as well. However, referral of these two specimens to S. gratus is not justified at present owing to the lack of teeth at other positions that belong to this species and the possibility that the expressed bimodality

of size in the present sample is owing to sampling bias. Nothing in the morphology of S. camptorhiza as presently understood precludes its derivation from S. kuszmauli. If so, the small size of S. camptorhiza relative to S. kuszmauli would then preclude it being a probable ancestor of the relatively large forms, S. gratus and S. teilhardi. Likewise, S. camptorhiza is an unlikely ancestor of S. jepseni: the condition of the anterior root and the anterior face of the crown on p4, S. jepseni, as described above are not derivable from S. camptorhiza without a reverse in polarity of these characters.

Subfamily Microcosmodontinae Holtzman and Wolberg 1977

Microcosmodon Jepsen 1930

Microcosmodon arcuatus n. sp.

(Figure 20; Table 9)

Etymology: arcuatus, L. past participle of arcuare, to bow; reference is to the highly arcuate p4 of this species.

Type specimen: UA 15114, Rp4.

Type locality: NW 1/4, sect. 23, Tp. 6, R. 24, W. 6, Loc. Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 16094-97 (total: 4), p4's; UA 15113, m1.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: p4 larger than in either Microcosmodon conus Jepsen 1930 or Pentacosmodon pronus Jepsen 1940 and having ridges more prominent than in the former but less so than in the latter; six serrations on p4 one more than in either M. conus or P. pronus; p4 profile most like that of M. conus; p4 relatively higher, more arcuate, and much shorter than in Microcosmodon woodi Holtzman and Wolberg 1977; m1 like m1, P. pronus, and unlike m1, M. conus, in possessing relatively few and simple cusps without complex grooves and ridges upon the slopes and labial cusps not tightly packed nor strongly crescentic; m1 relatively wider and with fewer cusps (cusp formula, 5:4) than m1, M. conus, and relatively narrower with more cusps (one more per row) and with relatively smaller lingual cusps than in P. pronus.

Description: p4. -- p4 is high and arcuate and bears six serrations. The height of the crown, from the base of the exodaenodont lobe to the

Figure 20. Microcosmodon arcuatus n. sp., Rav W-1: (a) labial, (b) lingual, and (c) occlusal view, UA 15114 (type), right p4 length 2.00, about X9; (d) occlusal, (e) labial, and (f) lingual view, UA 15113, left m1, length 2.25, about X9.

a
b

c
d

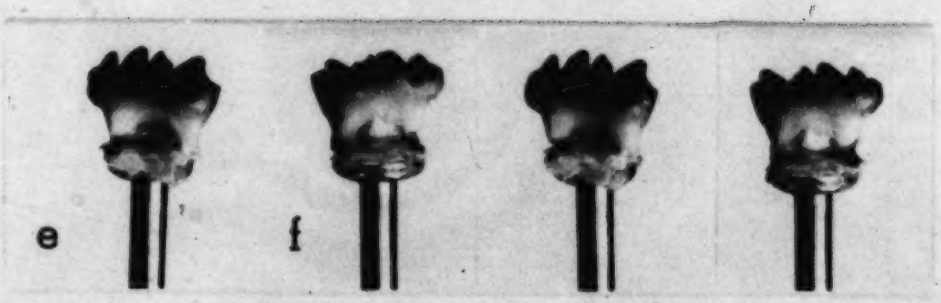
e
f

Table 9. Measurements of the dentition of Microcosmodon arcuatus n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
p4	L	3	2.00-2.30	2.15
	L1	2	.90-.95	.93
	h	2	1.45-1.55	1.50
m1	L	1	2.25	----
	W	1	1.10	----

apogee (1.90-2.00 mm for three specimens) is nearly as great as the crown is long. The first of the six serrations is distinct, set low on the anterior face of the crown, and is offset from the more posterior serrations; the second and ultimate serrations are likewise relatively offset from adjacent serrations although not to the same degree as the first serration; the third to fifth serrations are equally spaced. The ultimate serration is more cusp-like than the other serrations. Ridges arise both labially and lingually from each serration other than the first and the last (except on UA 16097 which has a slightly palpable lingual ridge arising from the first serration), and can extend ventrally one-third the distance to the base of the crown; the most anterior ridge descends at a steeper angle than those that follow. The posterior end of the crown is expanded to almost the same width as the anterior end owing to the presence of a cusp-like prominence on the posterolabial shelf. The crown overhangs the anterior root, forming the roof of the relatively weak anterobasal concavity; the leading edge of the anterior root bears a longitudinal groove. These features indicate p3 was likely present in this species. The anterior root is longer and more robust than the posterior root with little space between.

The profile of p4, M. arcuatus, is most similar to that of M. conus among known microcosmodontines and it is primarily on this basis that the Rav W-1 species is classified in the genus Microcosmodon. The lateral ridges are more prominent than in either M. conus or M. woodi but less prominent and shorter than in P. pronus. The apical crest bears one more serration than in either M. conus or P. pronus. Like P. pronus and M. woodi and unlike M. conus, the posterior width of the crown does not exceed the anterior width. The following features distinguish p4,

M. arcuatus, and p4, P. pronus: the posterior wall of p4, P. pronus, is high and approximately vertical, and abruptly terminates the posterior edge of the crown, whereas in P. arcuatus, it is gently convex; and the distance from the first to the second serration is relatively greater in P. pronus. p4, M. woodi, is much larger, relatively lower crowned and with deeper interserrational valleys than p4, M. arcuatus.

m1. -- A single m1 (UA 15113) is referable to this species (cusp ratio, 5:4). The form of the cusps is relatively simple; the intercusp valleys are not complex and the slopes of the cusps are devoid of grooves or ridges except for incipient development of such on the labial face of the last two lingual cusps. The crown is of uniform width although the cusp rows converge slightly anteriorly. The lingual cusps are higher and more labiolingually compressed than the labial cusps. The first two labial cusps are low, rounded and subquadrate; the remaining cusps of the labial row and those of the lingual row are subcrescentic and lean posteriorly. The third lingual and fourth labial cusps are damaged, precluding discussion of the relative height of the cusps although it is evident that the first labial and lingual cusps are lowest in their respective cusp row and the first labial cusp is lowest of all. The anterior margin of the crown is slightly concave and the labial cusp row protrudes farther anteriorly and posteriorly than does the lingual row; the posterior margin is convex and oriented obliquely relative to the longitudinal axis of the crown. The tooth bears two subequal, anteroposteriorly compressed roots with no evidence of accessory roots.

M1, M. arcuatus differs from m1, M. conus, as follows: the cusp morphology of m1, M. arcuatus, is comparatively simpler; the labial cusps

are not strongly crescentic nor as closely spaced; conspicuous grooves and ridges are lacking on the cusp walls; the number of cusps (5:4) is less than in M. conus (7-9:4-5 [Jepsen 1940, Krause 1977]); the cusp rows do not converge anteriorly as markedly; and the crown is relatively wider. In these features m1, M. arcuatus, resembles m1, P. pronus, more so than it does m1, M. conus. m1, P. pronus, however, is relatively wider, bears one fewer cusp per cusp row, and the lingual cusps are relatively larger. M1, M. woodi, has not been described.

The greater similarity of m1, M. arcuatus, with m1, P. pronus, rather than with m1, M. conus, is owing to the retention of the primitively simple cusp morphology and relatively low cusp number. As noted above, the profile of p4, M. arcuatus, is clearly more like that of M. conus than like that of P. pronus and is taken to indicate propinquity of relationship with the former at the generic level. The primitive P. pronus-like aspect of m1, M. arcuatus, is anticipated in an early member of the Microcosmodon-lineage.

Discussion: Until the discovery of M. arcuatus as well as two other unpublished forms discussed below, undoubted microcosmodontines were unknown from strata older than Tiffanian. Jepsen (1930 and 1940) originally described what is now the type genus and species of the subfamily, Microcosmodon conus and an additional genus and species, Pentacosmodon pronus, both from the Princeton Quarry, Polecat Bench Formation, Bighorn Basin, Wyoming. Apart from the type locality, P. pronus is known elsewhere only from the Jepsen Valley Quarry (above the Princeton Quarry level), Bighorn Basin, Wyoming (D.W. Krause 1979, pers. comm.). M. conus is now known from several locations and local faunas including: Roche Percee local fauna, Ravenscrag Formation, Saskatchewan (Krause 1977); Schaff Quarry, Polecat Bench

Formation, Wyoming (Krause 1977); Badwater Creek locality, Shotgun Member, Fort Union Formation, Wyoming (Krishtalka, et al. 1975); Sunday locality, Polecat Bench Formation, Bighorn Basin, Wyoming (D.W. Krause 1979, pers. comm.). A new species of Microcosmodon, similar to M. conus, from the UM locality SC-188 Quarry in the mid-Clarkforkian of the Bighorn Basin, Wyoming, is currently being described (D.W. Krause, 1979, pers. comm.).

Holtzman and Wolberg (1977) described a new species of Microcosmodon, M. woodi from the Circle locality, Tongue River Formation, Montana and the Brisbane locality, Tongue River Formation, North Dakota (since that time, new undescribed material referable to M. woodi has been recovered from a new site in the Paskapoo Formation on the Blindman River of Alberta [R.C. Fox 1979, pers. comm.]).

With the description of M. woodi, Holtzman and Wolberg (1977) provided a revised diagnosis of the genus Microcosmodon to include that species. None of the diagnostic characters they listed, however, distinguish Microcosmodon from the closely related genus Pentacosmodon, except that the labial face of the p4, unlike p4, Pentacosmodon, is smooth and almost featureless owing to a reduction of the lateral ridges. Hecht and Edwards (1977) point out that the loss or reduction of a character should be given relatively little weight in determining monophyly. In light of this, the near loss of lateral ridges in M. conus and M. woodi may distinguish these species from P. pronus in a purely phenetic sense but do not necessarily indicate that M. conus and M. woodi are more closely related to one another than either is to Pentacosmodon. When other characters are weighted more heavily than the reduction of lateral ridges, a different scheme of relationships is

apparent.

The profile of p4's has proved to be a useful taxonomic character for most groups of multituberculates and there is no reason to believe that the microcosmodontines are an exception. It might be argued that since microcosmodontines have undergone a relative reduction in p4 compared to other eucosmodontids and within their own lineage as well, that the profile of p4 is not a valid systematic character, as this tooth is tending to move away from functional constraints and hence is subject to great variability. Such a condition seems true in taeniolabids, such as Catopsalis and Taeniolabis, in which p4 is greatly reduced, shear is lost, and mastication is shifted posteriorly to the molar p; p4 is consequently relatively variable. In microcosmodontines, however, p4 is not nearly as reduced proportionally as in taeniolabidids, and is apparently as constant in profile as in other multituberculates that retain a shearing function for p4/P4. If therefore the profile of p4 is a useful character to assess relationships within the microcosmodontines, it is apparent that the profile of p4, M. woodi, is clearly larger, and relatively longer and lower than p4 of any other known microcosmodontine. I suggest on this basis that M. woodi be removed from the genus Microcosmodon and placed in its own genus. Rediagnosis of this form is deferred until the description of new material, including jaws, referable to this species, from the Paskapoo Formation of Alberta (Fox, in progress).

Archibald (1977) described a single, isolated, fragmentary p4 from the UCMP V74111 locality at the base of the Tullock Formation of Garfield County, Montana; he noted that the specimen closely resembled the p4 of P. pronus and M. conus. Archibald did not, however, refer

the unnamed basal Tullock species to the microcosmodontines and only questionably referred it to the Eucosmodontidae but now believes the specimen represents a new genus of microcosmodontine (J. Archibald 1980, pers. comm.). I suspect that the then large stratigraphic gap between the basal Tullock species and the Tiffanian microcosmodontines originally influenced Archibald to refrain from referring the basal Tullock species directly to the Microcosmodontinae. M. arcuatus, as well as an undescribed microcosmodontine in the Garbani Quarry assemblage (Puercan) (W.A. Clemens 1980, pers. comm.), is of significance in this respect as its occurence in the Rav W-1 assemblage extends the record of undoubted microcosmodontines to well into the Puercan. Consequently, I agree with Archibald that the close morphological similarity of the basal Tullock species with the microcosmodontines is owing to phylogenetic propinquity with certain species of that subfamily rather than to convergence.

It is not surprising that a microcosmodontine occurs in the basal Tullock. Both Archibald's species and M. arcuatus are not markedly different from the Tiffanian members of the subfamily and are quite distinct from other eucosmodontids contemporary with them, indicating the lineage had a history prior to Paleocene time. Holtzman and Wolberg (1977) argue convincingly that on the basis of certain primitive characters retained by the microcosmodontines yet absent in the earliest eucosmodontines, that the two subfamilies must necessarily have diverged prior to the age of the earliest known eucosmodontines (Djakokhta Formation [Campanian], Gobi Desert, Mongolian Peoples' Republic [Kielan-Jaworowska 1970]).

Holtzman and Wolberg (1977) suggested that M. woodi may have been ancestral to M. conus; however this suggestion is dubious. P. pronus is, as Holtzman and Wolberg (ibid.) pointed out, not derivable from M. woodi; the profile of p4, P. pronus, however, is clearly more like that of M. conus; in fact, the profiles are so similar that Jepsen (1930) at first referred specimens of P. pronus to M. conus. Holtzman and Wolbergs' scheme lacks parsimony in that it requires the development of the characteristic and highly distinctive, small, arcuate p4 independently in both lineages. M. arcuatus and Archibald's species are not derivable from M. woodi nor could they have given rise to that form, yet they are structurally quite similar to the probable immediate ancestors of M. conus and possibly P. pronus. Therefore, M. woodi is here viewed as having nothing to do with the ancestry of M. conus but rather represents a lineage that retained the primitively long and low p4 and that was likely isolated from other known microcosmodontines from a time prior to the existence of Archibald's basal Tullock species. According to this view the loss of ridges in M. woodi and M. conus must be considered as owing to parallelism. Nevertheless, this scheme is considered as more probable than the independent derivation of the distinctively short and arcuate p4 required by Holtzman and Wolbergs' scheme. The parallel loss of ridges in the M. woodi and M. conus lineages is likely associated with the reduction of p4 and the tendency to shift the task of mastication posteriorly to the molars. Such a condition arose convergently in taeniolabids; p4 was reduced and mastication was assumed by the molars with a resultant loss of the lateral ridges on p4. In view of this, parallelism in this feature within the microcosmodontines is less difficult to envisage.

Family Taeniolabidae Granger and Simpson 1929

Taeniolabis Cope 1882a

Taeniolabis sp.

(Figure 21)

Referred specimens: UA 15142, 15143, fragmentary ?M1; UA 15148, fragmentary m2; UA 15144-15147 (total: 4), fragments of molars not identifiable to position.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan; Puercan, Garbani Quarry, Tullock Formation, Garfield County, Montana.

Description: Seven fragmentary specimens that pertain to *Taeniolabis* were recovered from Rav W-1. UA 15145 consists of a half of a single cusp with an attached portion of an intercusp valley. Large swellings occur on the corners of the concave sides of this specimen imparting a shape not unlike certain cusps of the M1 and m1 of *Taeniolabis taoensis* Cope 1882a. UA 15147 consists of two transected cusps of unknown position. UA 15144 and 15146 are very worn and rounded by postmortem abrasion and provide little information except that they are parts of teeth that originally had two cusp rows and have enamel of a thickness comparable to that on the molars of large taeniolabidoids, such as *T. taoensis* and *Catopsalis calgariensis* Russell 1926.

UA 15142 is better preserved and consists of two large subcrescentic cusps with unworn apices: the broad convex surface of the cusps marks the posterior end of the specimen and the more nearly vertical planar

Figure 21. Taeniolabis sp., Rav W-1: (a) occlusal view, UA 15142, left ?M1, width of large cusp 3.80, about X7; (b) occlusal view, UA 15148, right m2, width 8.60, about X7.

a

b

surface, the anterior end. The apices of the cusps are deflected anteriorly and occur much anterior to, instead of directly over, the center of the cusp. Both cusps are about the same height (2.5 mm measured from the bottom of the intercusp valley to the apex) and width (3.8 mm), but the posterior cusp is longer anteroposteriorly (2.7 mm), more massive in profile and in occlusal view, and has a more convex posterior surface; the anterior cusp (2.2 mm in length) is more nearly rectangular in outline. A thick, blunt, low ridge arises from just below the apex of both cusps and descends obliquely, becoming more pronounced toward the posteromedial corner of the base of each cusp. The anteromedial corner of the posterior cusp is likewise inflated and crest-like, enhancing the concave medial surface of that cusp. A small tubercle occurs at the base of the anteromedial corner of the anterior cusp from which a thin sigmoidal ridge extends a short distance up the face of the cusp. The valley between the cusps is slightly oblique rather than perpendicular to a line defined by the apices of the cusps. The enamel is faintly wrinkled, in an irregular pattern. A vestige of the floor of the longitudinal intercusp valley is preserved along the breakage surface of the enamel of the lateral surfaces of the cusps, indicating that the cusps were bounded on both sides by another row of cusps. In both size and shape UA 15142 most closely resembles the cusps of the posterior half of the median row of the left M1, T. taoensis, particularly the sixth and seventh most anterior cusps, which on AMNH 6321, consist of an anteroposteriorly compressed cusp followed by a less compressed cusp with a broad groove in its lingual surface as in UA 15142.

UA 15143 consists of a single unworn cusp, much smaller and more

nearly quadrate than the cusps of UA 15142 but with similarly wrinkled enamel. The cusp is essentially pyramidal with three convex and one flatter, more nearly vertical, sides. The enamel extends ventrally much farther on one side than on the others and marks the external surface of the cusp. A ridge descends from the apex along the medial edge of the flattened side and swells into a distinct bulge. In relative size and shape, UA 15143 is similar to the fifth and sixth most anterior cusps of the labial row of the M1 of AMNH 16321 (T. taoensis); if actually from this position, UA 15143 is from the left side. It is probable that UA 15142 and 15143 were originally parts of the same tooth as evidenced by their nearly identical color and condition, and the fact they were recovered together during the screening of fossiliferous sediments in 1975. Unfortunately, a precise fit cannot be established between the two; the connecting edges, if originally present, are now broken away.

UA 15148 is readily identified as the anterior portion of a right m2 bearing the first cusp of both the labial and lingual cusp rows. The cusps are only slightly worn, subcrescentic and separated by a deep, narrow intercusp valley. The posterior wall of the larger lingual cusp is roughly perpendicular to the longitudinal intercusp valley, whereas the posterior wall of the smaller labial cusp extends obliquely anterolabially from the anteroposterior axis of the fragment. The wrinkling of the enamel of the anterior and lateral slopes of the cusps shows a vague dorsoventral lineation, a pattern more clearly developed on the posterior slope. The width of UA 15148 is 8.6 mm, a distance less than that known for T. taoensis but greater than that known for Lancian and Puercan species of Catopsalis, including Catopsalis joyneri

Sloan and Van Valen 1965 and Catopsalis foliatus Cope 1884. The width of UA 15148, however, is closely approached in m2, C. calgariensis (early Tiffanian) (UA 127, width = 8.5 mm), equalled in m2, Catopsalis fissidens Cope 1884 (Torrejonian), and slightly exceeded in the m2 of an undescribed species of Catopsalis from the Shotgun locality (early Tiffanian). Of these species, the cusp morphology of UA 15148 is most closely approached by m2, C. calgariensis (UA 127), but is distinguished on the basis of the following differences: the anteroexternal cusp is relatively and absolutely larger; when oriented in the same manner, the anterior face of the crown is more nearly perpendicular to the intercusp valley separating the cusps, whereas the anterior face of m2, C. calgariensis, is distinctly oblique; and the enamel is more heavily wrinkled. In respect to the first two features, UA 15148 is more similar to m2, T. taoensis, than to m2, C. calgariensis.

Discussion: All of the taeniolabid tooth fragments recovered from Rav W-1, with the exception of UA 15148, are of an appropriate size and shape that one could initially refer them to T. taoensis with some confidence. UA 15142, in particular, consists of two anteroposteriorly compressed cusps that are essentially rectangular in outline as are the molar cusps of Taeniolabis; they are quite unlike the quadrate molar cusps of Late Cretaceous and Puercan species of Catopsalis. Undescribed Catopsalis specimens from the Shotgun locality, converge on Taeniolabis in both size and molar cusp shape, but the cusps of UA 15142 are nonetheless larger than the cusps on M1 of even the Shotgun Catopsalis.

UA 15148, however, is much smaller than the corresponding part of m2 in T. taoensis, leading to the possibility that it is not

referable to the same genus and species as UA 15142-15147 but rather represents an undescribed species of Catopsalis, of similar size to C. calgariensis, the Shotgun Catopsalis and C. fissidens. Species of Catopsalis form a morphological series beginning with the Asian Catopsalis matthewi (Simpson) 1925 (?late Santonian and/or early Campanian) through to the North American form, Catopsalis calgariensis; this series exhibits among other trends, an increase in size (Kielan-Jaworowska and Sloan 1979). The m2 in species of Catopsalis does not achieve the size of UA 15148 until mid-Torrejonian and Tiffanian time. If UA 15148 does represent a species of Catopsalis, it is prematurely large.

Comparisons, however, of the Rav W-1 specimens with undescribed material referable to Taeniolabis (W. A. Clemens, in progress) from the Garbani Quarry (Puercan, Tullock Formation, Montana) reveals that the Rav W-1 specimens are virtually identical with them; consequently the Ravenscrag species is most likely conspecific with the Garbani form. Known teeth of the Garbani species appear to be similar in size and cusp morphology to T. taoensis but a significant difference is seen in the form of the m2: the first labial and lingual cusps in particular are relatively smaller, and are equal in size to those on UA 15148; the anterior end of the crown is narrower than the posterior end, while in T. taoensis the reverse is true, and the m2 of the Garbani form is also relatively more elongate and generally less lophate. In all these apsects the species represented by the Garbani and Rav W-1 specimens is more like the more primitive taeniolabids, such as the Lancian Catopsalis joyneri Sloan and Van Valen 1965, than is T. taoensis. Detailed description of the Garbani form and substantiation of my

brief comparisons remain to be done by W. A. Clemens. At present I interpret the Rav W-1 form to be conspecific with the Garbani form and refer both to Taeniolabis sp., recognizing that this species is distinct from T. taoensis and apparently less derived.

The Garbani Quarry (R. E. Sloan pers. comm.), Wagonroad (Gazin 1941) and Purgatory Hill (Van Valen and Sloan 1965) are estimated to be of late Puercan age, younger than the T. taoensis-bearing beds of the Nacimiento Formation. They are placed late within the Taeniolabis-zone, the youngest subdivision of the Puercan (Sloan 1969), largely on the basis of the supposed presence of T. taoensis at these localities. It appears, however, that the Taeniolabis species in at least the Garbani Quarry and Rav W-1 is distinct from T. taoensis and apparently less derived. Taeniolabis is known from a single specimen (a fragmentary M1, R. E. Sloan pers. comm.) from Purgatory Hill and from a single specimen (a fragmentary m1, Gazin 1941) from Wagonroad; it remains to be demonstrated whether these specimens are truly T. taoensis or are conspecific with the Garbani Quarry and Rav W-1 form. Other components of the fauna from Purgatory Hill are more like those from Garbani Quarry and Rav W-1 than like those from the T. taoensis-bearing beds of the Nacimiento Formation of the San Juan basin, and a similar age for the three former localities is suspected (see p. 234). The seemingly less derived nature of Taeniolabis from Garbani Quarry and Rav W-1 indicates that these localities are possibly older than the Taeniolabis beds of the San Juan Basin and possibly predate the Taeniolabis zone of the Puercan altogether. The presence of a less derived species of Taeniolabis in Garbani Quarry and Rav W-1 is not surprising in view of the fact that T. taoensis is very derived at its first appearance in

the San Juan Basin and the lineage must necessarily have had a relatively long previous history.

Order Primates

Suborder Prosimii

Infraorder ?Plesiadapiformes

Family uncertain[3]

Purgatorius Van Valen and Sloan 1965

Purgatorius sp.

(Figure 22)

Referred specimens: UA 16071, ?M1; UA 16070, M2; UA 16072-73, MX's.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: Four specimens have been recovered from Rav W-1 that appear to represent the upper dentition of a species of Purgatorius. Only one specimen, UA 16070 (M2) is adequately preserved to allow conventional measurement: L = 1.95, Ant - W = 2.70, Post - W = 2.90. The enamel of UA 16071 (?M1) is entirely dissolved away as if digested in the gut of a crocodile. UA 16071 is considerably smaller than UA 16071 so that positional difference in addition to the dissolution of the enamel is suspected. The lingual halves of two other upper

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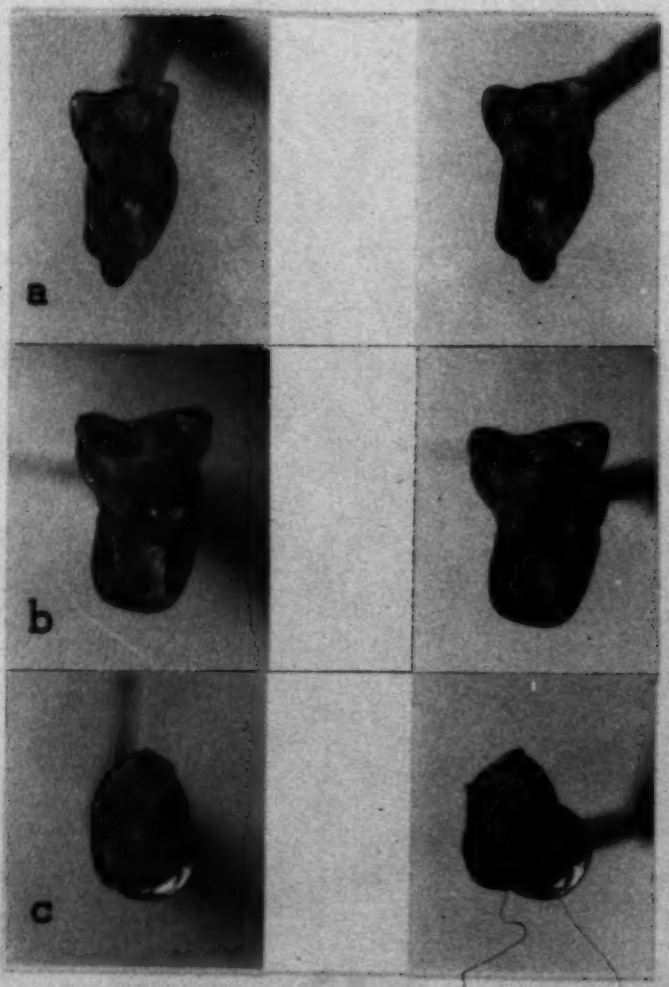
3) Purgatorius was originally described as a paromomyid (Van Valen and Sloan 1965) and subsequently regarded as such by most authors (e.g. Clemens 1974); however, Bown and Rose (1976) point out that Purgatorius cannot be confidently assigned to any known plesiadapiform family owing to its generalized dentition.

Figure 22. Purgatorius sp., Rav W-1: (a) occlusal view, UA 16071, right ?M1, about X10; (b) occlusal view, UA 16070, right M2, length 1.95, about X10; (c) occlusal view, UA 16073, right ?M3, about X10.


a
b
c

molars (UA 16072-73) are questionably referred here.

UA 16070 is like M2, Purgatorius unio (LACM 28128 [cast]; Kielan - Jaworowska et al. 1979: 21, fig. 12), except as follows: (1) 16070 appears relatively more transverse; 2) the ectoflexus is shallower and the lingual apex of the ectoflexus is shifted posteriorly (medial in M2, LACM 28128); 3) the parastylar lobe does not protrude as far labially; 4) the metaconule and premetaconular crista are better developed; 5) the postprotocrista is reduced and does not extend to the apex of the protocone; 6) the hypocone is less pronounced; 7) there is no evidence of a postprotocingulum (= nannopithex - fold), (variable in P. unio [Kielan - Jaworowska et al. 1979]); 8) the postcingulum extends relatively farther onto the lingual face of the protocone but the precingulum is less extensive lingually; 9) the lingual half of the crown appears less quadrate. These features are generally true of the other specimens referred to P. sp. except that the ectoflexus of UA 16071 is deeper and medially positioned as in P. unio. The hypocone of UA 16073 is greatly reduced; this specimen may be an M3. Additional specimens of the Rav W-1 species are required and comparisons with a larger sample of P. unio than has been done here is necessary to determine if all the noted differences with P. unio are consistent; nevertheless, it seems likely that a new species of Purgatorius is present in the Rav W-1 assemblage, and if so, it will not be named until additional material is obtained.

Discussion: Purgatorius, the only known pre-Torrejonian primate, was hitherto represented by two species, P. unio (Puercan, Tullock Formation) and P. ceratops Van Valen and Sloan 1965 (Lancian, Hell Creek Formation). The latter species is known from a single tooth

from the Harbicht Hill locality, McCone County, Montana; extensive washing and screening of localities in Garfield County, Montana of similar age to Harbicht Hill and in the same formation (Archibald 1977) has not produced a single specimen of Purgatorius so that the Lancian record of this genus has yet to be substantiated (W. A. Clemens [1980, pers. comm.] likewise questions the Lancian occurrence of Purgatorius). P. unio, however, is known from numerous specimens from Purgatory Hill and Garbani Quarry (Clemens 1980, pers. comm.), (both Tullock Formation, Montana). The Rav W-1 species, although as yet poorly known, represents an important addition to the meagre pre-Torrejonian record of primates. The discovery of a new species of primates in the Puercan is not surprising in view of the fact that at least five families of primates were present by late Torrejonian time (Bown and Rose 1976: fig. 5) and some of these (such as the plesiadapoids and microsyopids) were sufficiently divergent morphologically that their last common ancestor was likely pre-Torrejonian (Bown and Rose 1976: 134).

A few features of UA 16070 (M2), as compared to m2, P. unio, seem slightly more modified toward corresponding features of the primitive Torrejonian microsyopid (sensu Bown and Rose 1976) Palenochtha Gidley 1923; these features include: the relatively transverse crown, shallow ectoflexus, reduced hypocone and reduced postprotocrista. The determination of whether any real phylogenetic relationship exists between the Rav W-1 species and the microsyopids awaits additional material of the former.

Order Condylarthra

Family Arctocyonidae Murray 1866

Subfamily Oxyclaeninae Scott 1892

Oxyprimus Van Valen 1978

Oxyprimus albertensis (Fox) 1968

(Figures 23, 24; Table 10)

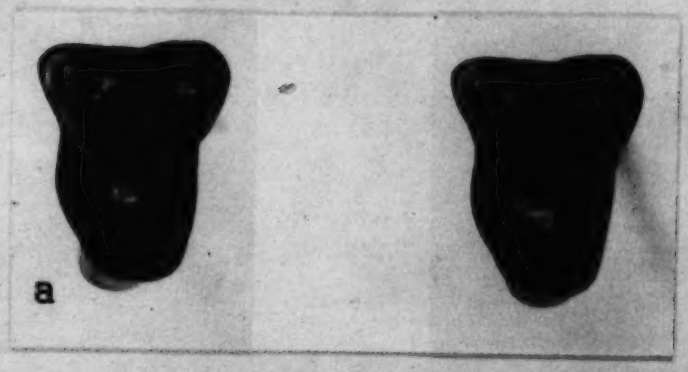
Referred specimens: UA 15120, 16022, M1's; UA 15131, M2; UA 16023-24, M3's; UA 16025, dp4; UA 15132, 16026-27 (total: 3), m2's; UA 15139, 16029, m3's; UA 16030, mX.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan; Puercan, ?Paskapoo Formation (or ?Porcupine Hills Formation, see Carrigy 1970, 1971; Krause 1978), well core near Calgary, Alberta; Puercan, Purgatory Hill, Tullock Formation, McCone County, Montana.

Description: Two isolated lower jaws referrable to O. albertensis have been described in detail (Fox 1968; Russell 1974); therefore, description of corresponding elements in the present sample has been omitted to avoid redundancy. I mention an aberrant m3, UA 16029, questionably referrable to O. albertensis, that bears various teratological features: a large cusp, equal in size to the primary talonid cusps, occurs between the entoconid and hypoconulid; the base of the trigonid on the labial side is bent anteriorly; and the talonid is abnormally steep in its inclination. The talonid is unusually large and the talonid cusps are greatly hypertrophied as compared to UA 1338 (type), and UA 15139 (m3, O. albertensis), but the trigonid is of similar form,

Figure 23. Oxyprimus albertensis, Rav W-1: (a) occlusal view, UA 15120, left M1, length 3.80, about X7; (b) occlusal view, UA 15131, left M2, posterior width 5.80, about X7; (c) occlusal view, UA 16023, right M3, length 3.10, about X7.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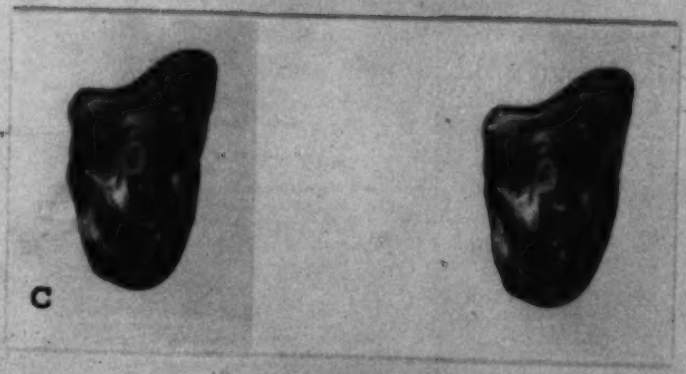
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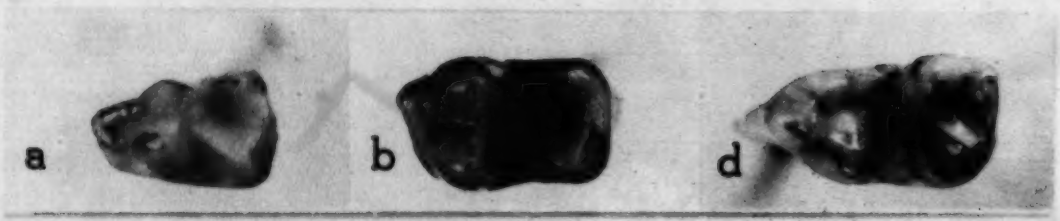
Figure 24. Oxyprimus albertensis, Rav W-1: (a) occlusal view, UA 16025, left dp4, length 3.50, about X7.5; (b) occlusal and (c) labial view, UA 15132, left m2, length 4.10, about X7.5; (d) occlusal, and (e) lingual, UA 15139, right m3, length 4.6, about X7.5.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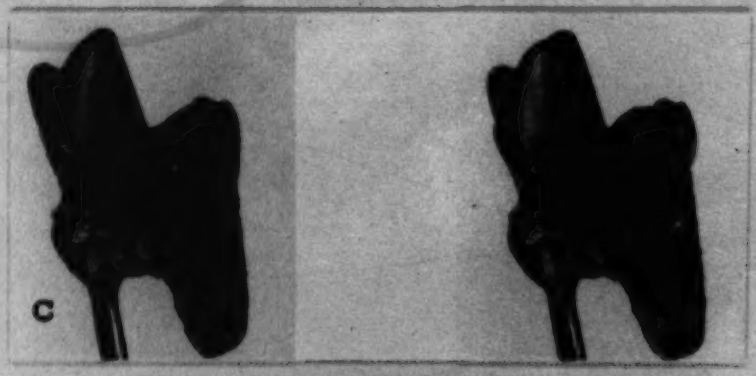
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Table 10. Measurements of the dentition of *Oxyprimus albertensis*, Loc. Rav W-1

Element	Dimension	N	OR	M
M1	L	1	3.80	----
	Ant-W	1	4.60	----
	Post-W	1	4.80	4.80
M2	L	-	----	----
	Ant-W	1	5.80	----
	Post-W	1	5.90	----
M3	L	2	3.10-3.30	3.20
	Ant-W	2	4.70-4.80	4.85
	Post-W	2	4.30	4.30
dp4	L	1	3.50	----
	Tri-W	1	1.90	----
	Tal-W	1	2.30	----
m2	L	3	4.10-4.20	4.15
	Tri-W	3	2.75-2.80	2.78
	Tal-W	3	2.6 - 2.9	2.78
m3	L	1	4.60	----
	Tri-W	1	2.55	----
	Tal-W	1	2.20	----

though slightly larger.

dp4. -- A single dp4, UA 16025, is of an appropriate size and structure to warrant allocation here. The paraconid is slightly compressed anteroposteriorly; the trigonid basin opens lingually. The talonid has subequally spaced primary cusps and is relatively deep. The hypoconulid is small and crest-like.

M1 - M3. -- The upper molars of O. albertensis have not previously been described and will therefore be considered in detail here. The sample of the upper dentition is not large and consists of two M1's, a single M2 and two M3's, which are associated with the lower dentition of O. albertensis on the basis of size and occlusal fit. The crowns of the upper molars are relatively transverse and the primary cusps are subconical. The conules are subequally developed on M1, while on M2, and especially M3, the metaconule is relatively weaker and is positioned lower on the labial face of the protocone than the paraconule. The internal wings of the conules are weak; the external wings are much stronger and extend labially to become continuous with the ectocingulum (except the postmetaconular crista of M3 which is interrupted posterolabially owing to reduction of the metastylar lobe). The hypocone is absent on M3 and variably developed on M1 and M2, ranging from nothing more than a posterolingual swelling of the postcingulum in UA 15120 and 15131, to a more conspicuous, cusp-like structure on UA 16022. The pre- and postcingulum extend well onto the lingual face of the protocone and are almost lingually continuous on M3. Labially, the pre- and postcingulum terminate before reaching the external wings of the conules. The ectocingulum is low and narrow. The stylar shelf is narrow on M1 but becomes much broader on M2. The ectoflexus on M1 is shallow, a feature

apparently characteristic of M1 in all known members of the genus and distinct from the relatively deeper ectoflexus of M1 in the related species Protungulatum donnae Sloan and Van Valen 1965.

Discussion: In addition to the specimens recovered from Rav W-1, material referable to O. albertensis includes: the type specimen (UA 1338), a single fragmentary dentary recovered from a well core a few miles north of Calgary, Alberta (Fox 1968); a fragmentary dentary (ROM 12865) from the Pine Cree locality (Ravenscrag Formation) a few miles east of Rav W-1 (Russell 1974); and undescribed material from Purgatory Hill (Tullock Formation), (Van Valen 1978: 53). Fox (1968) originally described the type of O. albertensis under the name Prothryptacodon albertensis, realizing its less derived state as compared to Prothryptacodon furens Simpson 1935a, the only other species of the genus. Russell (1974) described the Pine Cree jaw under the name Carcinodon aquilonius Russell 1974 but later, Van Valen (1978) recognized the close similarity of P. albertensis and C. aquilonius and synononimized the two in a new genus, Oxyprimus. The type is considerably smaller and the molars, especially m3, appear less elongate, with greater anteroposterior compression of the trigonids than in the Pine Cree jaw and corresponding elements in the Rav W-1 sample; there is no apparent difference in the inclination of the paraconids on UA 1338 and ROM 12865 (contra Russell 1974). O. albertensis may be a composite species but in the absence of a larger sample from Alberta, and the consequent lack of a firm concept of variability in the Alberta form, I agree with Van Valen (1978) that insufficient differences exist to maintain specific distinction of the Alberta specimen from the Saskatchewan sample. O. albertensis remains a reasonable structural and possibly phylogenetic antecedent of

Prothryptacodon Simpson 1935a, as Fox (1968) suspected.

Fox (1968) suggested the type specimen of O. albertensis was of Torrejonian age owing to its apparent alliance with P. furens; however, the discovery of O. albertensis in undoubted Puercan assemblages at Purgatory Hill and Rav W-1 indicates the type specimen (UA 1338) is likely of Puercan age, as well. Consequently, UA 1338 is considerably older than other known Paleocene mammal assemblages from Alberta, all of which are Tiffanian or latest Torrejonian in age (Russell 1958, 1965b; Krause 1978). The absence of early Paleocene faunas from the central plains of Alberta led Russell (1932, 1965b) to believe that this span of time was represented by an erosional gap between Late Cretaceous and Paleocene sediments in that region; but, he suspected that early Paleocene sediments might likely exist to the west, in the much thicker upper Cretaceous and Paleocene sequence exposed along the uplifted western segment of the Alberta syncline (Russell 1965b). The recognition of a Puercan age for the type specimen of O. albertensis indicates Puercan sediments are present in the subsurface of the western part of the central plains of Alberta and makes more reasonable the anticipation of discovering Puercan mammals in the uplifted Paleocene strata to the west.

Oxyclaenus Cope 1884

Oxyclaenus corax n. sp.

(Figures 25,26; Table 11)

Etymology: κοραξ, Gk. raven; reference is to the village of Ravenscrag, Saskatchewan, near which the known specimens of this species were discovered.

Type specimen: UA 15127, LRM2.

Type locality: NW. 1/4, sect. 23, Tp. 6, R. 24, W. 6; Loc. Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 15128, 15154-55 (total: 3), M1's; UA 15190, M2's; UA 15126, 15156-57 (total: 3), M3's; UA 15199, M1; UA 15124-25, 15194-97 (total: 6), m2's; UA 15198, 15200 - 203 (total: 5), mX's.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: Upper molars of similar size and form to Oxyclaenus simplex (Cope) 1884 but M3 less reduced; M1 and M2 with deeper ectoflexus and wider stylar shelf; metastylar lobe of M2 relatively broader and more labially protruding; conules more lingually placed; variability of features of m2 overlapping with m2, O. simplex, but generally with straighter posterior margin, more swollen paraconid, more medially curving entocristid, broader talonid and more anteriorly positioned entoconid than in O. simplex; on m2, trigonid more turgid, paraconid lower talonid basin less expanded and entoconid more anteriorly placed than in Oxyclaenus pearci Gazin 1941; lower molars also resembling those of Loxolophus hyattianus (Cope) 1885, but talonid not as expanded nor talonid basin as deep; paraconid more internally placed, trigonid

Figure 25. Oxyclaenus corax n. sp., Rav W-1: (a) occlusal view, UA 15128, right M1, length 5.15, about X7; (b) occlusal view, UA 15154, left M1, posterior width 5.80, about X7; (c) occlusal view, UA 15127 (type), right M2, length 5.50, about X7; (d) occlusal view, UA 15126, right M3, length 3.80, about X7.

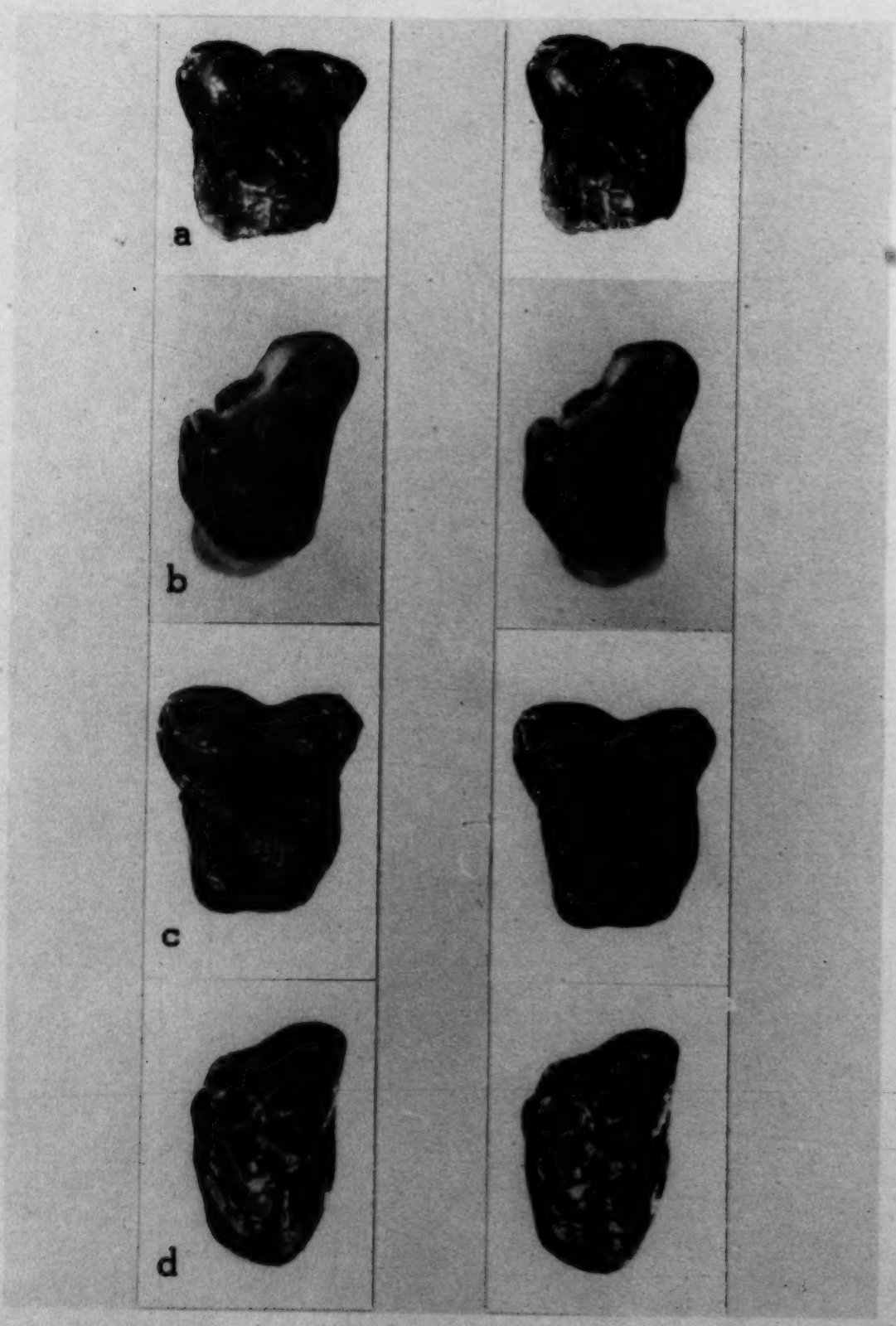
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Figure 26. Oxyclaenus corax n. sp., Rav W-1: (a) occlusal, and (b) labial view, UA 15199, right m1, length 4.85, about X7; (c) occlusal, and (d) labial view, UA 15125, left m2, length 5.60, about X7.

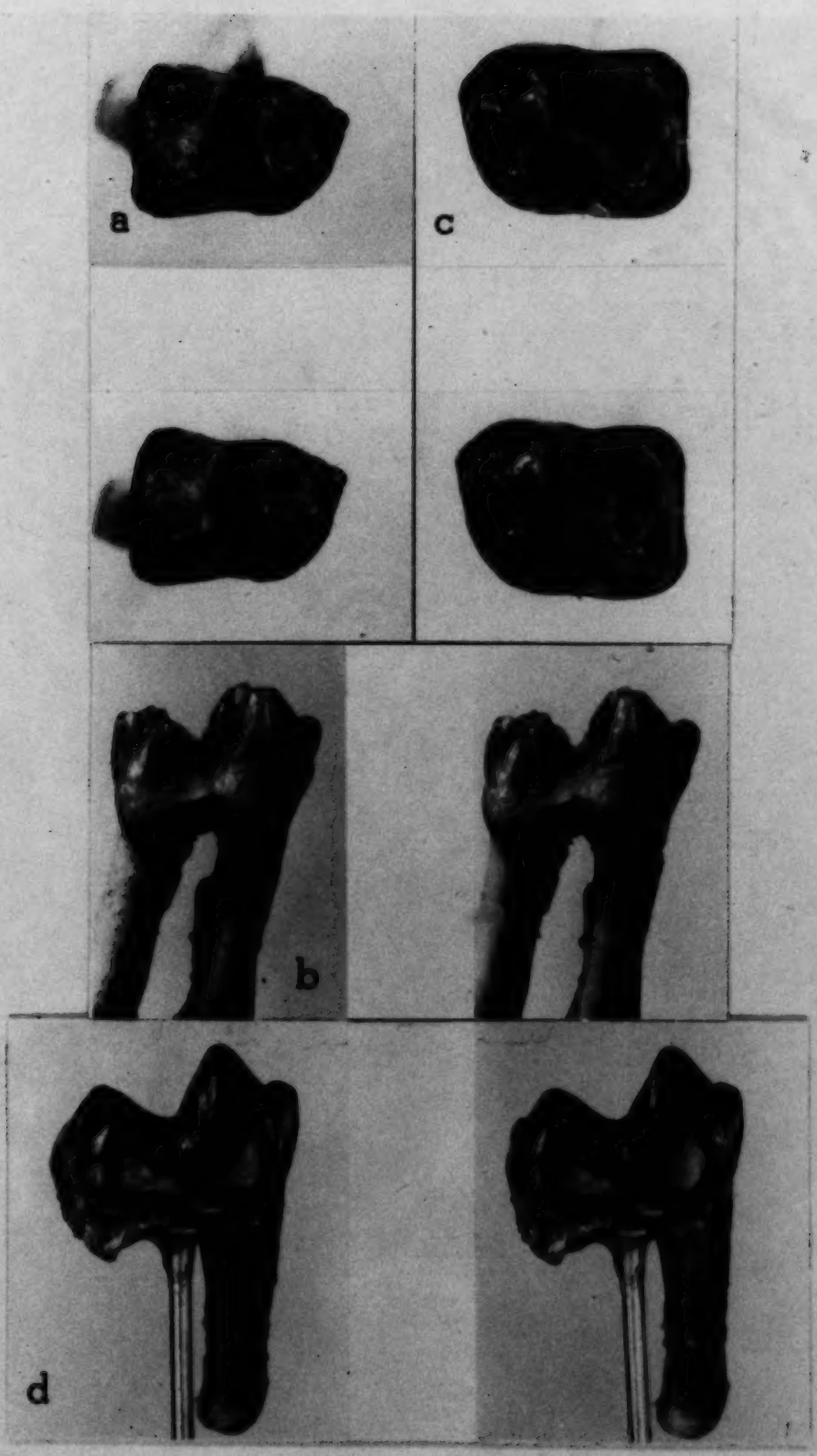
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Table 11. Measurements of the dentition of Oxyclaenus corax n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
M1	L	2	4.85-5.15	5.00
	Ant-W	-	----	----
	Post-W	1	5.80	----
M2	L	1	5.50	----
	Ant-W	1	6.00 (est.)	----
	Post-W	1	6.20 (est.)	----
M3	L	3	3.50-4.05	3.77
	Ant-W	3	5.30-5.80	5.58
	Post-W	3	4.85-5.25	5.12
m1	L	1	4.85	----
	Tri-W	1	3.40	----
	Tal-W	1	3.80	----
m2	L	6	5.20-5.60	5.40
	Tri-W	6	4.00-4.65	4.30
	Tal-W	6	4.20-4.60	4.35

relatively higher; upper molars more highly transverse, slightly smaller and less bunodont than in L. hyattianus; metaconule of M3 not displaced posteriorly.

Description: M1 - M3. -- M1 and M2 are quadrate in outline lingually but expand anteriorly and posteriorly labial to the pre- and postcingulum. The conules are strong, concave labially and bear pronounced external wings that sweep labially to become continuous with the external cingulum, but on M3, the postmetaconular crista terminates at the base of the metacone owing to the reduction of the metastylar lobe. Internal conular wings are present, but are weak on some specimens. The pre- and postcingulum are well developed but do not extend across the lingual face of the protocone and terminate labially before reaching the external wings of the conules. The lingual extension of the precingulum on M3 varies from no more lingual than the protocone (UA 15157) to well onto the lingual face of the the protocone (UA 15126). The postcingulum widens posterolabially on M1 and M2 but the hypocone itself is not large. The metacrista and paracrista are distinct (the former is lacking on M3) and curve labially; the pre- and postprotocrista and the centrocrista are prominent. The postprotocrista of M2 is swollen just posterior to the protocone. The lingual slope of the protocone on M1 and M2 parallels the lingual slope of the paracone and metacone but is more shallowly inclined on M3.

The upper molars of O. corax closely resemble those of O. simplex (AMNH 3107, type) in size and crown pattern but differ as follows: M3 is relatively and absolutely less reduced; M2 is slightly less transverse; the metastylar lobe of M2 is relatively broader and more labially protruding; the conules, as in Oxyclaenus cuspidatus (Cope) 1884, are

more lingually placed; the ectoflexus is much deeper on M1 and M2 and the stylar shelf is slightly wider. The conules appear relatively farther apart but the type specimen of O. simplex, AMNH 3107 (a cast of which was used in this comparison), is extensively worn, precluding detailed comparison of the conules and certain cusps and crests; nonetheless, the differences noted indicate the Rav W-1 species is distinct from O. simplex, although apparently closely related.

An overall resemblance with the upper molars of certain species of Chriacus Cope 1883, such as Chriacus baldwini (Cope) 1882b, is evident, but unlike that species, there is no tendency in O. corax for development of a lingual shift of the hypocone nor of a continuous lingual cingulum.

The upper molars of O. corax, are slightly smaller, much less quadrate and less bunodont than in L. hyattianus (AMNH 16343), and the metaconule of M3 is not posteriorly displaced, as in that species.

m1 - m2.-- The known lower molars are of oxyclaenine pattern, that is, tritubercular-sectorial with a moderately high trigonid and a distinct, though slightly reduced, lingually placed paraconid. m1 is represented by a single specimen, m2 by several, and m3 is unknown. m1 is smaller than m2 but is similar in all features except that the trigonid is relatively less transverse and the paraconid is less appressed to the metaconid. m2 is subquadrate in outline; the talonid can be wider than the trigonid (3 of 6 specimens). The hypoconulid is small, well separated from the entoconid and occurs slightly lingual to the long axis of the crown. The mesoconid is well developed (UA 15124) to absent (UA 15197). The ectocingulid is generally complete and bears a variably developed cuspule at the hypoflexid. UA 15124 (m2) occurs in a fragment of the

dentary that measures 7.4 mm in depth below the anterior alveolus on the labial side.

The entocristid is variable in its orientation. In the three smallest specimens (UA 15124, 96-97), the entocristid is deflected anterolingually toward the lingual wall leaving a small talonid notch; in the three largest specimens (UA 15125, 15194-95) it is parallel with the long axis of the crown or curves labially at its anterior extent, closing the talonid notch. Similar variation in the orientation of the entocristid and development of the talonid notch is also present in the related species, O. simplex (entocristid curved lingually, talonid notch closed in UCMP 31814; entocristid deflected anterolingually, talonid notch open [AMNH 3107 (type), 59997]). This, and the fact that size variation in the m2's of O. corax is gradational rather than truly bimodal, indicates the expressed variation is not of taxonomic significance.

m1 and m2, O. corax, are similar to corresponding teeth of several species of arctocyonids, particularly those of Oxyclaenus. The molars are smaller than in O. cuspidatus and the entoconid is relatively closer to the trigonid than in that species and usually closer than in O. simplex, as well, although there is considerable overlap with the latter (UA 15125 and AMNH 59997, for example, are indistinguishable in this feature). Generally, the paraconid is slightly more inflated, the talonid is relatively wider and shallower and the posterior margin of the crown is straighter than in O. simplex, but here, too, considerable overlap exists. Differences separating O. corax from O. simplex are seen primarily in the upper dentition. Similarities with Oxyclaenus pearcei are also evident, but O. corax differs as follows: trigonid more turgid and paraconid relatively lower, talonid basin less expanded

and entoconid more anteriorly placed.

The larger m2's referred to O. corax resemble m2, L. hyattianus (AMNH 16343) but the talonid in O. corax is less expanded and not as deep and the paraconid is more lingual. Similarities in size and crown outline are also evident with m2, Chriacus calenancus Van Valen 1978 (p. 64, pl. 2) from Purgatory Hill, but the postvallid is less steep, the hypoconulid and entoconid are not as close together and the paraconid is not labially shifted in O. corax.

Discussion: Most features of the upper molars of O. corax appear less derived than those of O. simplex, including the wider stylar shelf, the more lingually placed conules, the broader and more labially protruding metastylar lobe, the deeper ectoflexus and the less reduced M3; if M2 of the type, O. simplex, is characteristic of the species, M2, O. corax, appears slightly more quadrate, in which case O. corax is more derived in that feature.

The polarity of character states of the lower molars of O. corax and O. simplex is difficult to assess as there is considerable overlap of variation. None of the known species of Oxyclaenus seem derivable from any other species in the genus owing to the mosaic of primitive and derived characters distributed among them.

Van Valen 1978 (p. 63, fig. 2) suggested that among known arctocyonids, Protungulatum most closely approaches the ancestral

condition from which Oxyclaenus was derived. I suggest that Oxyclaenus[4] is as easily or more easily derivable from some species of Oxyprimus Van Valen 1978, such as Oxyprimus erikseni Van Valen 1978.

Features of the lower molars common to both the Lancian species O. erikseni (and other species of Oxyprimus) and Oxyclaenus and differing from Protungulatum include: the posterior expansion of the talonid basin in m1 and m2, and a tendency for a labial shift of the entocristid resulting in closure of the talonid notch. These features become better developed in later species of Oxyprimus, such as Oxyprimus albertensis (Fox) 1968 and probable derivatives of Oxyprimus, such as Chriacus (Cope) 1883, Prothryptacodon Simpson 1935a, and early hyopsodontids. Certain species of Loxolophus, such as L. hyattianus, L. pentacus and a new species of Loxolophus described below also exhibit these features indicating propinquity of descent possibly lies with Oxyclaenus rather than with other loxolophines. Much pertinent material, however, is not at hand to properly evaluate this suggestion.

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4) except possibly O. cuspidatus; M2 in this species is relatively more transverse than in O. corax and O. simplex, the ectocingulum, especially on the metastylar and parastylar lobes, is much more robust, and the internal cingulum is better developed. Such features indicate O. cuspidatus is more likely derived from a species like Oxyprimus galadrielae Van Valen 1978 though not necessarily that species: M3, O. cuspidatus, does not appear derivable from M3, O. galadrielae.

Subfamily Loxolophinae Van Valen 1978

Loxolophus Cope 1885

Loxolophus schizophrenus n. sp.

(Figure 27; Table 12)

Etymology: schizophrenus, from schizophrenia, split mind; allusion is to the presence of characters similar to both Loxolophus hyattianus and Oxyclaenus simplex.

Type specimen: UA 15107, left dentary fragment with m1-m3.

Type locality: NW. 1/4, sect. 23, Tp. 6, R. 24, W. 6; Rav W-1, about 3.5 km WNW. of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 16001, M1; UA 15130, 15206-7 (total: 3), M2's; UA 15208-9, M3's; UA 15129, 15192-93, 16021 (total: 4) m1's; UA 15106, 15191, m3's.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: Molars most similar to those of Oxyclaenus simplex and Loxolophus hyattianus, although distinguished from the former in that M3 and m3 are less reduced; lingual face of protocone of M2 and M3 more gently inclined; parastylar lobe of M1 less protruding; lower molars slightly more bunodont; trigonid lower; talonid basin less deep; paraconid, especially on m3, less reduced; entocristid labially deflected and talonid notch more nearly closed; entoconid placed more anteriorly; molars smaller than those of L. hyattianus and upper molars more transverse, metaconule in M3 not shifted posteriorly; talonid in m1 and m2 less expanded and less deep, paraconid not shifted labially;

Figure 27. Loxolophus schizophrenus n. sp., Rav W-1: (a) occlusal view, UA 16001, left M1, anterior width 5.70, about X7 (b) occlusal view, UA 15130, left M2, length 4.85, about X6.5; (c) occlusal view, UA 15209, right M3, length 3.90, about X6.5; (d) occlusal, (e) lingual, and (f) labial view, UA 15107 (type), left dentary fragment, depth of jaw below anterior alveolus of m2 on labial side, 7.50, about X3.5.

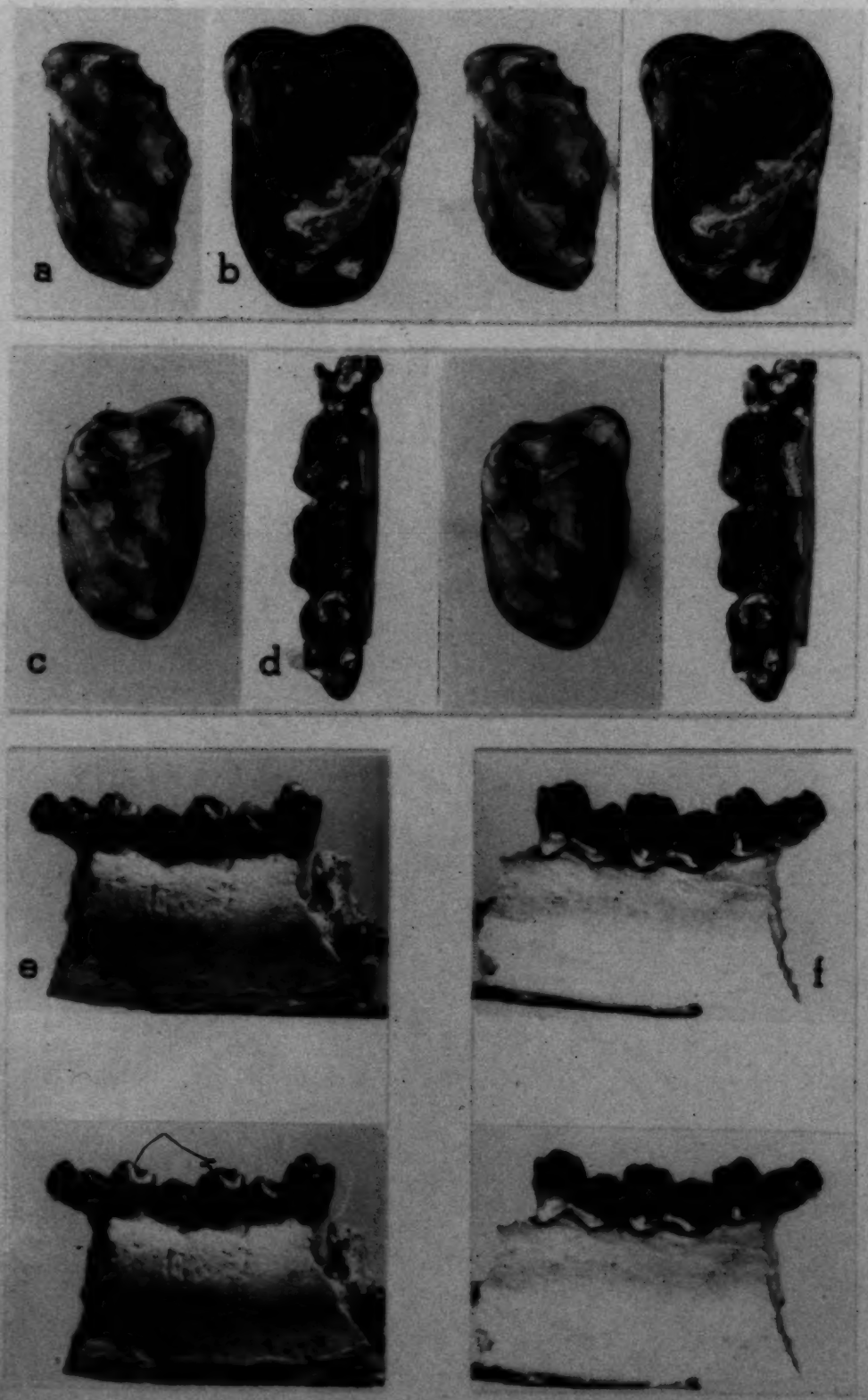
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Table 12. Measurements of the dentition of Loxolophus schizophrenus n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
M1	L	-	--	-
	Ant-W	1	5.70	-
	Post-W	-	--	-
M2	L	3	5.00-5.10	5.03
	Ant-W	3	6.40-6.80	6.63
	Post-W	3	6.60-7.10	6.78
M3	L	2	3.90-4.00	3.95
	Ant-W	2	6.20-6.25	6.23
	Post-W	2	5.55-5.90	5.73
m1	L	4	4.35-5.00	4.63
	Ant-W	4	2.75-3.15	2.96
	Post-W	5	3.15-3.40	3.28
m2	L	1	4.80	-
	Ant-W	1	3.80	-
	Post-W	1	3.70	-
m3	L	3	5.60-6.10	5.77
	Ant-W	3	3.20-3.60	3.40
	Post-W	3	2.90-3.15	3.05

unlike either O. simplex or L. hyattianus hypocone of M1 and conules of M1 and M2 relatively more lingually placed, hypoconulid nearer mid-line of tooth, entoconid more anteriorly positioned.

Description: M1-M3. -- M1 is known from a single fragmentary specimen (UA 16001) that is missing the metacone, metastylar lobe and the postcingulum. The tooth appears to have been subquadrate in outline prior to breakage. M2 and M3 are subquadrate in outline as well but are more transverse than M1. The hypocone on M1 is a small, rounded, distinct cusp, circumferentially about the size of the conules although relatively taller; on m2 and m3 the hypocone is relatively less pronounced and takes the form of a minute cuspule or simply a thickening of the postcingulum. The precingulum on M1 does not extend onto the lingual face of the crown but instead, terminates at a point co-linear with the paracone and paraconule; on m2 and m3 the precingulum is relatively more extensive lingually and on m2, may be continuous with the postcingulum. The paraconule and metaconule are subequally developed; the former is positioned slightly closer to the apex of the protocone. The pre- and postcingula terminate labially before reaching the external wings of the conules. M3 is relatively unreduced.

The three M2's referred here are moderately variable. They are of similar size and little worn. One (UA 15130) bears a continuous internal cingulum, while on UA 15207 a short gap and on UA 15206 a longer gap occurs lingually between the pre- and postcingula. The ectocingulum is thicker and the parastylar lobe is more projecting on UA 15206-7 than on UA 15130. A small, ridge-like, transversely oriented mesostyle, seen on UA 15206, is lacking from the others. The hypocone

is strongest and most labially placed on UA 15207. The paraconular crista is strongly developed on UA 15130 but is weak or absent on the others. A comparable degree of variation in the development of the internal cingula to that seen here is present on M2, Protungulatum donnae Sloan and Van Valen 1965 (compare UA 6676 and UA 6632), and on M2, Mimotricentes subtrigonus (Cope) 1881; and similar variation in the form of the parastylar lobe is seen in the latter (compare AMNH 100579C and 100579F, Swain Quarry). In view of these comparisons and the fact that the variable features are distributed in a mosaic fashion among the three specimens in question, the variation is likely without taxonomic significance.

As in O. simplex (AMNH 3107, type), the upper molars of L. schizophrenus are more highly transverse than those of L. hyattianus (AMNH 16343), the hypocone is slightly weaker, and the metaconule on M3 is not displaced posteriorly. As in L. hyattianus, the parastylar lobe of M1 is not as broad and is less protruding from the crown, the lingual face of the protocone on M2 and M3 is more gently inclined and the M3 is less reduced than in O. simplex.

m1-m3. -- The lower molars are of a simple tritubercular pattern like that seen in Protungulatum and Oxyprimus although larger, more bunodont and more turgid than in those species. The paraconid of m2 and m3 is lower, more inflated and more appressed to the metaconid than on m1 but is nonetheless distinct on all molars and is positioned labially. The trigonid basin opens on either side of the paraconid on m1, but the lingual side is closed on m2 and m3, owing to partial adnation of the paraconid and metaconid. The metaconid and protoconid are subequal circumferentially but the latter is slightly taller.

The talonids on m1 and m2 are about as long anteroposteriorly as the trigonids. The entocristid curves medially, closing the talonid notch. The cristid obliqua, on m1 and m2, terminates slightly labial to, and on m3, directly below the protoconid-metaconid notch. The hypoconulid of m1 and m2 is the smallest of the talonid cusps and quickly becomes indistinct with wear; it is nearly medially positioned but is still slightly closer to the entoconid than to the hypoconid. The entoconid is distinct on m1 and m2 but becomes less conspicuous on m3, owing to partial reduction and fusion with the hypoconulid. The entocristid on m3 bears a minute mesoconid and one to several small cuspules occur on the postcristid between the hypoconulid and entoconid. The dentary of the type specimen is 7.50 mm deep below the anterior alveolus of m2 on the labial side.

Van Valen (1978) synonomized Carcinodon filholianus (Cope) 1888 with O. simplex. C. filholianus was previously distinguished from O. simplex on the basis of its relatively larger m3 and the more labial placement of the paraconid (Matthew 1937). If Van Valen's synonomy is valid, the range of variation in these features in the resultant sample seems unusually large (compare, for example, AMNH 16347, O. simplex and AMNH 16366, C. filholianus). Regardless of the validity of Van Valen's synonomy, the lower molars of L. schizophrenus are distinguished from either species on the basis of the following features: m3 is relatively less reduced; the trigonid is relatively lower, the talonid is less deeply basined and the cusps are slightly more bunodont; the paraconid, especially on m3, is slightly less reduced; the hypoconulid is nearer the midline of the tooth and the entoconid is more anteriorly placed, the entocristid is deflected labially toward the posterior face of the

metaconid, closing or nearly closing the talonid notch, while in C. filholianus (AMNH 16366) and O. simplex, the entocristid extends anterolingually to the posterolingual corner of the metaconid, leaving the talonid notch more open (less so in UCMP 31814, O. simplex). There is no tendency in L. schizophrenus for the development of a lingual cingulum evident in the type, O. simplex, and AMNH 16366 (C. filholianus).

m1 and m2, L. schizophrenus, resemble the smallest specimens at those positions referred to O. corax, but the molars of O. corax are larger, with a straighter posterior margin and a more labially protruding hypoconid.

In the strictly phenetic sense the lower molars of L. schizophrenus differ more greatly from those of L. hyattianus than from lower molars of O. simplex. In L. schizophrenus, the molars are much smaller, the talonid of M1 and M2 is not as deep and the paraconid is more lingual than in L. hyattianus; but m3 in L. hyattianus and L. schizophrenus is not as reduced, the talonid notch is more completely closed and the crowns are more bunodont than in O. simplex.

Discussion: L. schizophrenus appears to represent a primitive species of Loxolophus. Those features (described above) of the molars of L. schizophrenus that are more similar to corresponding features of O. simplex than to those of L. hyattianus are symplesiomorphic and are anticipated in a primitive species of Loxolophus Generic affinity of L. schizophrenus with species of Loxolophus, (especially L. hyattianus) rather than with species of Oxyclaenus is substantiated on the basis of the following similarities with the former: m3 and M3

are unreduced; molars are relatively bunodont; parastylar lobe of M1 is not protruding; entoconid of lower molars is labially deflected, closing the talonid notch. All of these characters states except the first are synapomorphic for L. schizophrenus and L. hyattianus and indicate these two species are more closely related to one another than either is to species of Oxyclaenus.

Baioconodon Gazin 1941

Baioconodon cf. B. denverensis Gazin 1941

(Figures 28, 29; Table 13)

Referred specimens: UA 15153, DP4; UA 15141, incomplete M1; UA 15109, 15152, M2's; UA 15110, M3; UA 15111, m1; UA 15112, m2.

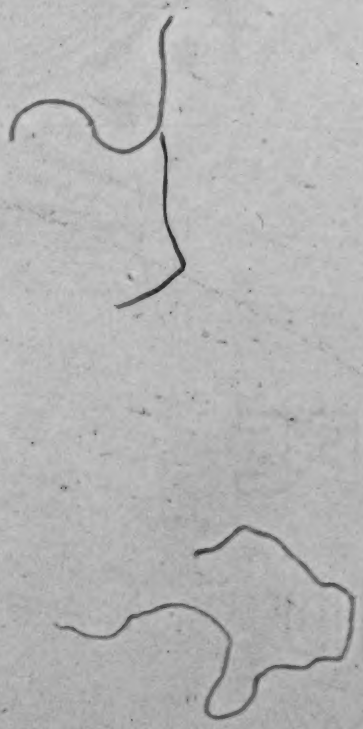
Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: Baioconodon cf. B. denverensis is known entirely from isolated teeth. The tooth positions represented are known from single specimens, except M2 for which two specimens have been recovered, one complete and one fragmentary. Association of the teeth referred here is based on their relatively large size as compared to corresponding teeth of most mammals in the Rav W-1 assemblage, and by comparison with articulated dentitions known for other species in the genus, including the type species, Baioconodon denverensis Gazin 1941 (Puercan, South Table Mountain, Denver Formation, Colorado) and Baioconodon antiquus (Simpson) 1936 (Puercan, Barrel Springs Arroyo, Nacimiento Formation, New Mexico). Comparisons with B. denverensis are based on the original description and figure (Gazin 1941: 293) of the type and only specimen, a dentary fragment having m2-m3. Comparisons with B. antiquus are based on a cast of the type and hitherto only specimen, a maxillary fragment having P3, M1-M3 and with a new specimen, UCMP 92649, a maxillary fragment having M1-M3, here referred to this species.

DP4. -- A single specimen, UA 15153, appears to be a DP4. The

Figure 28. Baioconodon cf. B. denverensis, Rav W-1: (a) occlusal view, UA 15141, left M1, about X6.5; (b) occlusal view, UA 15109, right M2, anterior width 8.90, about X6.5; (c) occlusal view, UA 15110, right M3; anterior width 8.30, about X6.5.

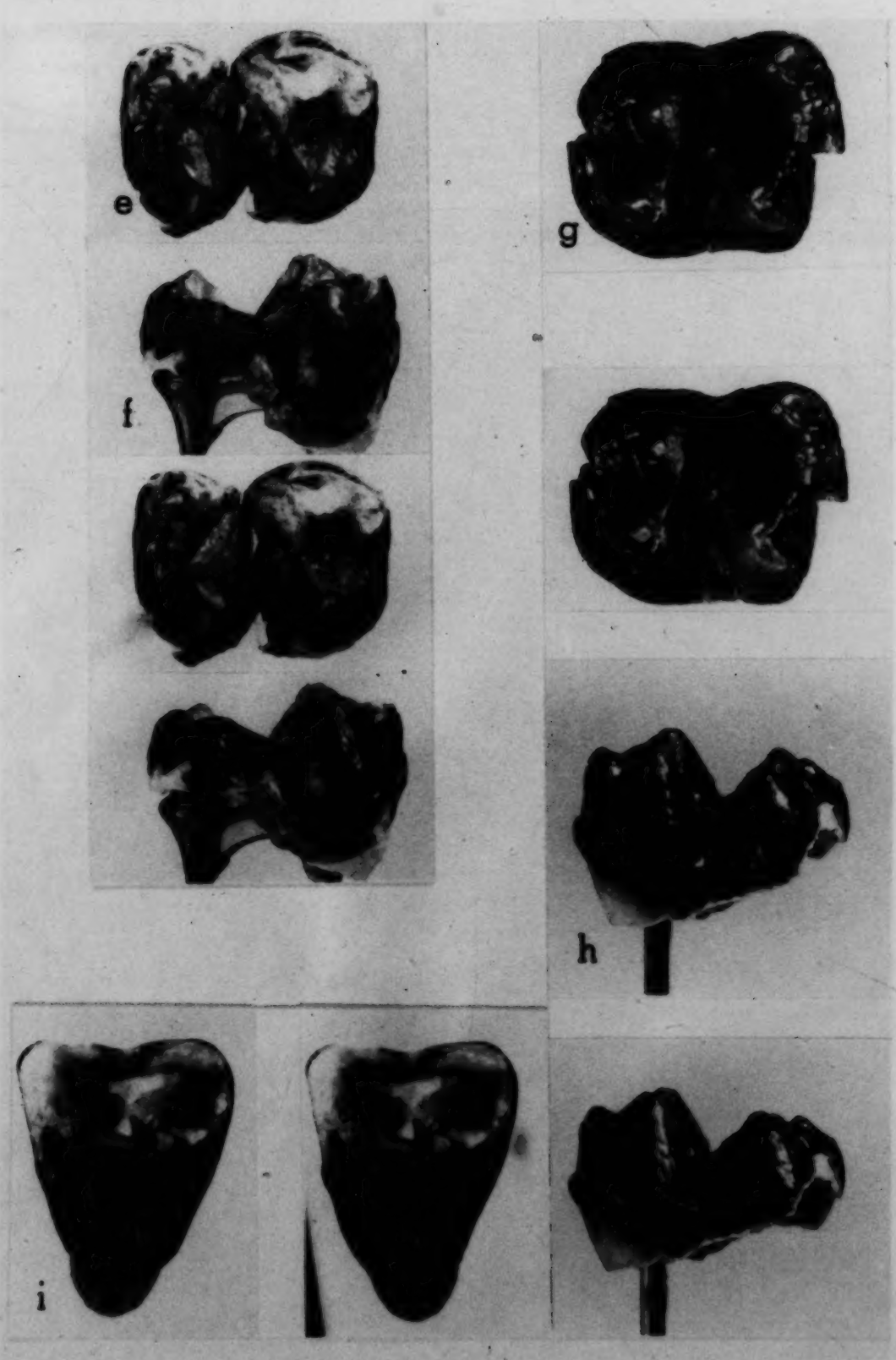


a

b

c

Figure 29. Baioconodon cf. B. denverensis, Rav W-1: (e) occlusal, and (f) labial view, UA 15111, right m1, trigonid width 5.30, about X6.5; (g) occlusal, and (h) labial view, UA 15112, left m2, trigonid width 5.70, about X6.5; (i) occlusal view, UA 15153, left DP4, length 5.15, about 6.5.


e
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g
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i

Table 13. Measurements of the dentition of Baioconodon cf. B. denverensis, Loc. Rav W-1.

Element	Dimension	N	OR	M
DP4	L	1	5.15	--
	Ant-W	-	----	--
	Post-W	1	5.55	--
M2	L	1	6.80 (est.)	--
	Ant-W	1	8.90	--
	Post-W	1	9.20	--
M3	L	1	5.80 (est.)	--
	Ant-W	1	8.30	--
	Post-W	1	7.35	--
m1	L	1	6.80 (est.)	--
	Tri-W	1	5.30	--
	Tal-W	-	----	--
m2	L	1	7.30	--
	Tri-W	1	5.70	--
	Tal-W	1	5.80	--

tooth is closely similar to M1 but is smaller, less transverse and has thinner enamel; the pulp cavities of the roots are hollow, lacking development of secondary dentine as expected in a deciduous premolar. As on M1, the conules and hypocone are well developed and the precingulum bears a small pericone. The two labial roots are broken off but the lingual root is intact, as is the dentine of the undersurface of the crown (except for the barely palpable beginnings of a replacement pit between the roots); the animal evidently died before the tooth was shed. Extensive wear occurs on the prevallum, exposing dentine along most of the precingulum, preparaconular crista and parastylar lobe. Wear is likewise evident in the intercusp valley between the paracone and metacone and, unlike M1-M3, at the bottom of the trigon basin. The extent of the wear on this specimen is by no means unique among arctocyonids; conspicuous wear is also reported on, for example, DP4, Thryptacodon australis Simpson 1935b (Holtzman 1978).

M1-M3. -- UA 15109, M2 and 15110, M3, are probably from the same individual, as indicated by their nearly identical color, condition and degree of wear, and by the fact that they were recovered together during the screening of the fossiliferous sediments in 1975. M1 and M2 are essentially rectangular in outline. The hypocone is well developed and bulges posteriorly, enhancing the concavity of the posterior margin. On M3, the lingual margin is convex rather than quadrate, owing to the reduction of the hypocone. The precingulum extends relatively farther lingually on M2 and M3 than on M1, but is not continuous with the postcingulum across the lingual face of the protocone. The conules are well developed with strong external wings; the postparaconular crista is present on M1 (and DP4), weak or absent

on M2, and absent on M3. On UA 15152 (a fragment of an unworn M2), a prominent cuspule occurs immediately anterior to, and a second cuspule posterior to the protocone, on the protocristae; both cuspules occur on M1 and DP4 as well, although much less well developed there. An unworn M3 has yet to be recovered, so that the presence or absence of these cuspules cannot be determined.

On M2 the stylar shelf (broken off in UA 15141 [M1]) is broad labial to the metacone and becomes narrower labial to the paracone; a small mesostyle is present and small tubercles and crenulations are present on the shelf and on the ectocingulum. The trigon basin is deep and remains unworn, even with pronounced wear to the rest of the crown. In these specimens extensive wear has obliterated much of the primary cusps, hypocone and conules on a plane essentially parallel to the overall plane of the crown; equally pronounced wear has also occurred on the anterior surface of the parastylar lobe and preparaconular crista.

The upper molars are readily distinguished from those referred to B. antiquus on the basis of the following differences: the M2 of B. cf. B. denverensis is relatively more transverse and has a broader stylar shelf, especially in the area labial to the metacone; the mesostyle of M2 is less developed; the precingulum of M1 does not extend as far lingually; the ectoflexus of m2 and M3 is deeper; m3 is larger, its hypocone is stronger and the mesostyle, although very weak, is not entirely lacking, as it is on M3, B. antiquus. M3 is less reduced in B. cf. B. denverensis than in B. antiquus, and was probably unreduced in B. denverensis as well, as indicated by the unreduced m3 in that species.

m1 and m2. -- m1 and m2 are known from single specimens, m3 is unknown. Occlusally, the crowns appear transverse and subquadrate in outline. The primary cusps of the talonid and trigonid are well developed and distinct. The paraconid, although relatively reduced, is positioned lingually and is offset from the metaconid. A thick low ridge bridges the paraconid-metaconid notch. The paraconid-protoconid notch is also bridged by a thick low ridge that first extends transversely from the paraconid and then, at the point of intersection with the notch, bends sharply toward the protoconid. This ridge is weaker on m1, particularly so labially. The talonid is highly transverse and anteroposteriorly compressed. The entoconid and hypoconulid adjoin one another but are not adnate; the entoconid is the smallest circumferentially and shortest of the talonid cusps. The entocristid terminates before reaching the trigonid wall, leaving a distinct talonid notch. The ectocingulid is discontinuous across the labial surface of the protoconid and hypoconid. The pre- and postcingulid are well developed. On m2, a small cuspule occurs on the ectocingulid at the hypoflexus (this region is broken on m1), and a short cingulid extends anteriorly from the talonid notch around the posterolingual corner of the trigonid, weakens and finally terminates at a point directly below the apex of the metaconid. On UA 15111 (m1), distinct interdental wear striations that parallel the labial surface of the metaconid are present on large pre- and postvallid wear surfaces on the protconid and hypoconid; these provide an indication of the direction of jaw motion in this animal.

UA 15112 (m2) is very similar to m2, B. denverensis (USNM 16621, type), as illustrated and described by Gazin (1941), but a few minor

differences can be noted: the crown is slightly smaller and slightly less transverse; the cuspule at the hypoflexus on the ectocingulid is not as large; the ectocingulid is not continuous labially on m2 (or on m1) but is continuous on m2 and m3, B. denverensis.

Discussion: Van Valen (1978) proposed derivation of Baioconodon and all other members of the Loxolophinae from Ragnarok. If the characters of the upper molars of, for example, Ragnarok nordicum (Jepsen) 1930 represent primitive character states for the subfamily, Baioconodon cf. B. denverensis appears to be less derived than Baioconodon antiquus as indicated by the following: the M2 is relatively more transverse than in B. antiquus; the stylar shelf of m2 is broader, particularly in the region labial to the metacone; the mesostyle of M2 is less well developed (a mesostyle is lacking on m2, R. nordicum, according to Jepsen's illustration); the ectoflexus is deeper on m2; the precingulum of m1 is less lingually extended; the hypocone on M3 is better developed; M3 is larger. The only feature that appears to be more derived in B. cf. B. denverensis is the presence of an incipient mesostyle on M3, which is lacking on M3 of B. antiquus. The stronger mesostyle on m2, B. antiquus, indicates that its absence from M3 may be secondary, owing to the relative reduction in the size of the crown as a whole.

The differences noted between the lower molars of B. cf. B. denverensis and the type of B. denverensis are of uncertain taxonomic significance owing to small sample size. I suspect, however, that B. cf. B. denverensis may eventually prove to be a new species of Baioconodon, on the basis of preliminary comparisons with casts at the University of California Museum of Paleontology of new undescribed

material provisionally identified as B. denverensis from the Alexander locality (Puercan, Denver Formation) of eastern Colorado (Middleton, in progress). However, further discussion of the relationship of the Rav W-1 form and B. denverensis awaits positive identification and description of the Alexander material.

Subfamily Triisodontinae Scott 1892

?Eoconodon Matthew and Granger 1921

?Eoconodon sp.

(Figure 30)

Referred specimens: UA 15151, ?P4; UA 16047, MX; UA 16048, M3.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

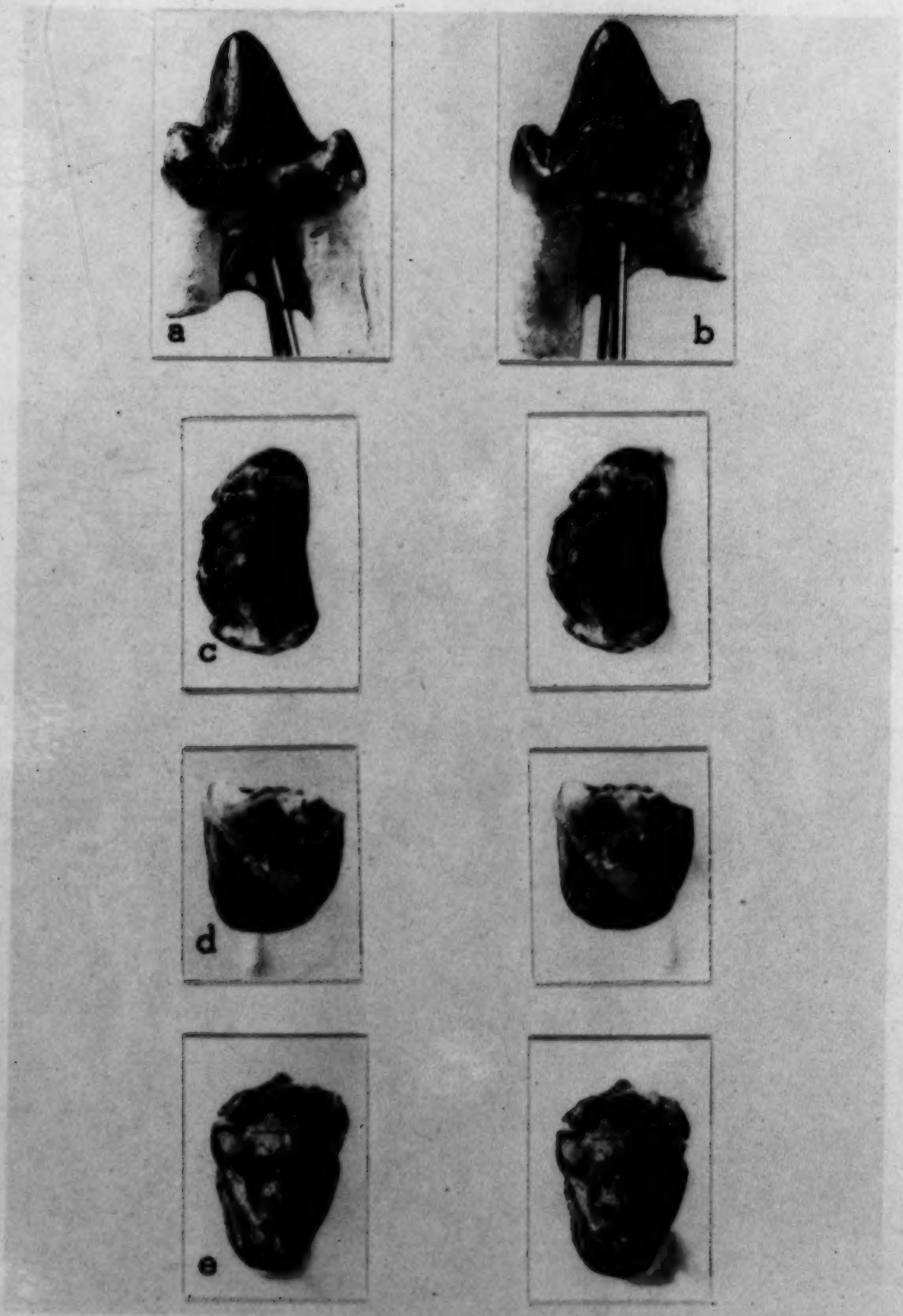
Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, Saskatchewan.

Description and discussion: Three fragmentary specimens have been recovered from Rav W-1 that likely represent a species of Eoconodon. The sample consists of a ?P4 (UA 15151, L = 7.25) with the protocone broken away, the lingual half of an ?M1 or ?M2 (UA 16047), and an M3 (UA 16048, L = 5.00 [est.], Post-W = 6.40) with much of the parastylar lobe broken off.

UA 15151 (?P4) consists of a large conical paracone with a well developed parastyle and metastyle. A large accessory cusp adjoins the parastyle labially. The ectocingulum is complete but is weak at the ectoflexus. UA 15151 is thought to be a P4 judging by the curvature of the parastylar lobe as compared to P4, Eoconodon coryphaeus (Cope) 1885 (AMNH 3181); however, in the absence of the protocone, the positional identity cannot be ascertained.

UA 16047 represents the lingual half of either an M1 or M2. The pre- and postcingula are well developed but are not continuous lingually. The hypocone and conules are distinct but relatively reduced. The lingual surface of the protocone is steeply inclined. A remnant of the lingual surface of the base of the paracone and metacone indicates

Figure 30. ?Eoconodon sp. (a) labial, (b) lingual, and (c) occlusal view, UA 15151, left ?P4, length 7.25, about X5; (d) occlusal view, UA 16047, right MX, about X5; occlusal view, UA 16048, right M3, posterior width 6.40, about X5.


a
b
c
d
e

these cusps were partially connate.

UA 16048 (M3) is like UA 16047 in corresponding features except that the hypocone is absent and the metaconule, although worn, was apparently more reduced. The metacone is reduced but the postmetaconular crista is not interrupted posterolabially and is continuous with the ectocingulum. The parastylar area is mostly broken away but it appears to have protruded labially.

Known dental elements of ?Eoconodon sp. are much smaller than corresponding elements of E. coryphaeus (formerly E. heilprinianus [Cope] 1882b, until Van Valen 1978: 58) and near the size of Eoconodon gaudrianus (Cope) 1888 (estimated by comparison with measurements of M3, E. gaudrianus, in Cope 1888: 326). Unlike M3, E. gaudrianus (and M3, E. coryphaeus), the pre- and postcingula of UA 16048 are not lingually continuous.

Two species of Eoconodon that appear to be of similar size to ?E. sp. are present at Purgatory Hill (Van Valen 1978: 58) although only one has been described and that only on the basis of lower molars. The Rav W-1 species could conceivably be a small species of Goniacodon Cope 1888 although, as in species of Eoconodon, the m3 (UA 16048) appears relatively less reduced than in that genus. A more refined assessment of the relationships of the Rav W-1 species awaits the recovery of additional material.

Family Periptychidae Cope 1889c

Subfamily Anisonchinae Osborn and Earle 1895

Anisonchus Cope 1881

Anisonchus cf. A. oligistus Gazin 1941

(Figure 31; Table 14)

Referred specimens: UA 16041, P4; UA 16042, M2; UA 16043, M3; UA 16044, dentary fragment with ml-m3; UA 16145, ?m2.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: P4. -- A single damaged P4 (UA 16041) is referred here. Both the anterolabial and posterolabial corners have been chipped off. The protocone is well developed and about two-thirds the length of the paracone. If an incipient metacone was present it has been obliterated by wear. Pre- and postcingula are present and a weak cingulum extends anteriorly from the metastylar area a short distance onto the labial surface of the paracone. A similar cingulum apparently extended posteriorly from the parastylar area but is now mostly broken away. Three roots were originally present.

UA 16041 is structurally very similar to P4, A. oligistus (USNM 15522, cast), and P4, Anisonchus gillianus Cope 1882c (AMNH 16461, cast), but is smaller than the latter; the former is poorly preserved but the protocone appears relatively smaller and the lingual surface, steeper on UA 16041.

M2-M3. -- Both M2 and M3 are represented by single specimens. M2 (UA 16042) is subquadrate in outline; the lingual half of the crown

Figure 31. Anisonchus cf. A. oligistus, Rav W-1: (a) occlusal, UA 16041, left P4, about X7.5; (b) occlusal view, UA 16042, left M2, anterior width 5.40, about X7.5; (c) occlusal view, UA 16043, left M3, posterior width 4.40, about X7.5; (d) occlusal, about X5, (e) labial, and (f) lingual view, UA 16044, left dentary fragment, length m3 4.40, about X3.5.

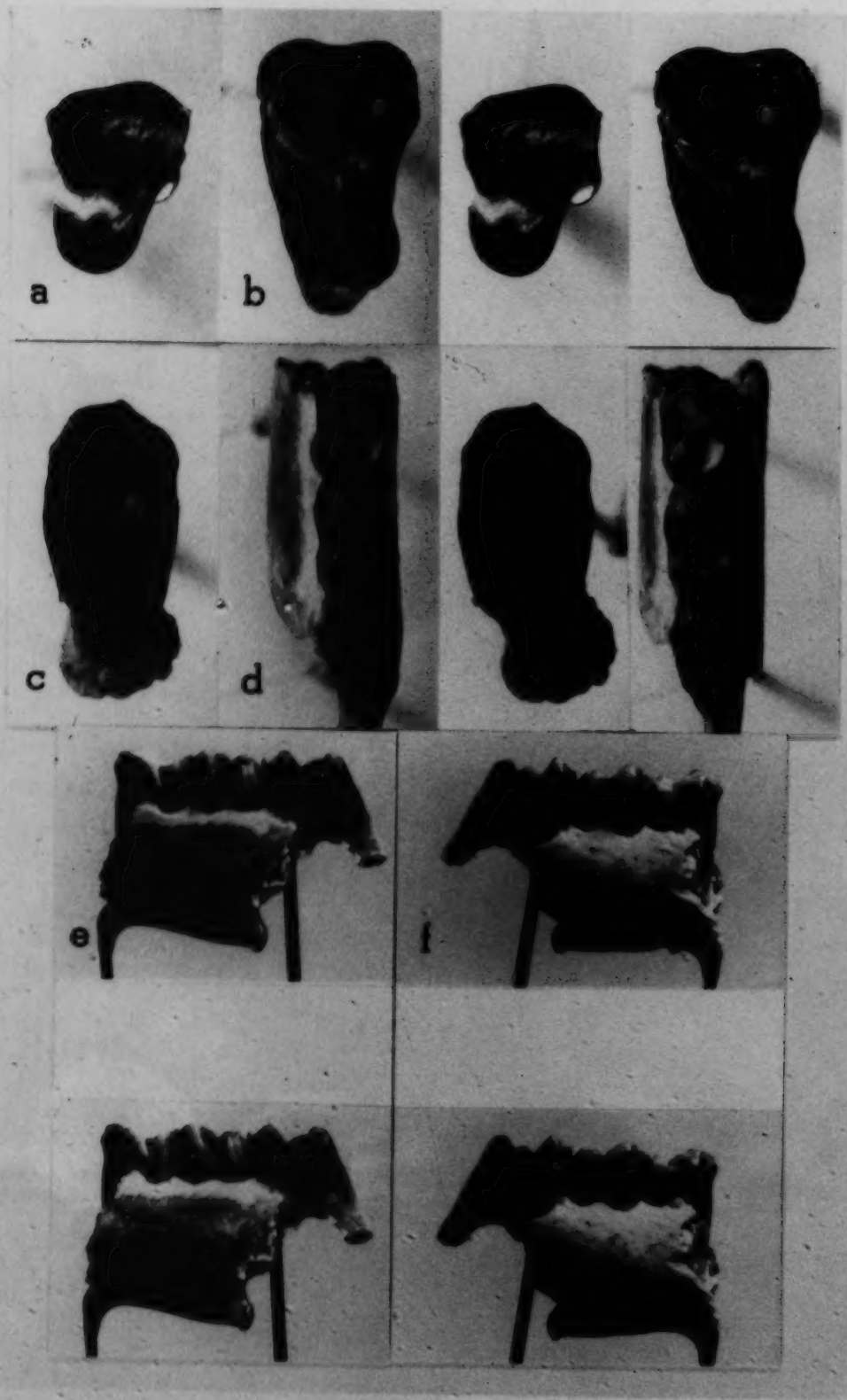

a
b
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Table 14. Measurements of the dentition of Anisonchus cf. A. oligistus, Loc. Rav W-1.

Element	Dimension	N	OR	M
P4	L	-	--	-
	W	1	4.75	-
M2	L	1	3.90 (est.)	-
	Ant-W	1	5.40	-
	Post-W	1	5.60	-
M3	L	-	--	-
	Ant-W	-	--	-
	Post-W	1	4.40	-
m1	L	1	3.70	-
	Tri-W	1	2.30	-
	Tal-W	1	2.40	-
m2	L	1	3.55	-
	Tri-W	1	2.65	-
	Tal-W	1	2.60	-
m3	L	1	4.40	-
	Tri-W	1	2.60	-
	Tal-W	1	2.20	-

veers posteriorly owing to the posterior protrusion of the hypocone. The lingual margin is squared, the posterior margin is concave and the anterior margin is convex. The paracone is the highest of the principal cusps, the protocone and metacone are of subequal height and the hypocone is the shortest, rising to the height of the metaconule. The paraconule is more appressed and positioned higher on the labial surface of the protocone than is the metaconule; the metaconule, unlike the paraconule, is offset posteriorly from the body of the protocone. The preparaconular crista extends from the apex of the paraconule well up the lingual face of the paracone, whereas the premetaconular crista terminates abruptly at the base of the metacone. The preparaconular crista and postmetaconular crista are confluent with the pre- and postcingulum respectively. The pre-, ecto-, and postcingulum are continuous around all but the lingual margin of the crown. The precingulum extends well onto the lingual face of the protocone and hooks upward before terminating at a point directly below the apex of the protocone. The labial face of the hypocone is concave and is bordered anteriorly, apically and posteriorly by a continuous crista that is posteriorly confluent with the postcingulum. The centrocrista and postmetacrista are well developed (the latter is mostly broken away on UA 16042); however, the preparacrista is very weak and fades away before reaching the base of the paraconule. The stylar shelf is narrow and lacks any indication of a mesostyle except that the ectocingulum, in labial view, is slightly raised in that region. The parastyle is greatly reduced and consists of nothing more than a slightly raised segment of the labial extent of the precingulum.

UA 16042 is almost indistinguishable from M2, A. oligistus

(USNM 16192, type and 18522), except for a few differences: on UA 16042, the posterior margin of the crown is distinctly concave, rather than straight, owing to the greater posterior protrusion of the base of the hypocone; the postcingulum, between the hypocone and postmetaconular crista, is much shorter; and the lingual surface of the protocone and the lingual and labial surfaces of the hypocone are more steeply inclined.

On the single M3 (UA 16043) referred to this species, the parastylar area is broken away. The crown pattern is essentially like that of M2, but the metacone is reduced and the hypocone is smaller. Unlike M2, the pre- and postcingulum are relatively broad and the lingual extent of the precingulum is marked by a small protostyle that bulges lingually so that the lingual margin of the crown appears slightly concave. A certain degree of variation of these features occurs between differing molar positions in specimens of A. oligistus and A. gillianus at hand but not to the degree seen between UA 16042 and 16043. Owing to the small sample size, the observed variation between M2 and M3 is interpreted, for the present, as individual variation but may prove to be of taxonomic significance.

m1-m3. -- The lower dentition is represented by a dentary fragment with m1-m3 (UA 16044) and an isolated talonid (UA 16045, width = 2.60) that is probably an m2. The m3 of the dentary fragment was isolated from the dentary when recovered, and the anterior root is broken off, precluding a precise fit with the remnant of the alveolus on the dentary. The color, condition, relative degree of wear, articulation of the interdental facet with that of m2, and the fact that the m3 and the dentary fragment were sorted from the same bag of concentrate in 1975, strongly suggests that they were parts of the same individual and have

been restored as such.

On UA 16044, the talonid is wider than, subequal with, and narrower than the trigonid on m1, m2 and m3, respectively. The paraconid is well offset from the protoconid, and the trigonid basin opens lingually between the paraconid and metaconid in typical anisonchine fashion. The entocristid converges anteriorly with the cristid obliqua and closes the talonid notch. The cristid obliqua meets the trigonid at a point anterior to the protoconid-metaconid notch. The ectocingulum is lacking on all the molars of UA 16044 except at the ectoflexus (and between the hypoconid and hypoconulid of m3) but is continuous across the labial surface of the hypoconid on UA 16045.

The paraconid of m2 and m3 leans anteriorly and is appressed to the hypoconulid of the preceding molar. A bulge at the base of the hypoconulid of m1 and m2 fits into a concave surface defined by the base of the paraconid and the top of the precingulid of the successive molar. The postcingulid of m1 and m2 overides the precingulid of the adjacent molar. This arrangement of interdigitating surfaces eliminates interdental space between the molars and likely prevented food material from being wedged between the molars and from damaging the interdental gingiva. The gingiva at the lateral surfaces of the molars was apparently protected by the lateral swelling of the base of the crowns, which would have deflected food materials laterally, away from the gingiva. The imbrication of the postcingulid of m1 and m2 over the precingulid of the successive molar would demand the eruption of first m1 and then m2 and m3, respectively. A similar arrangement is present in a dentary fragment (AMNH 16461) of the related species, A. gillianus. In this specimen, the heel of p4 fits under the precingulum of m1 indicating

ml was in place prior to the eruption of p4. On UA 16044 and AMNH 16461 and other anisonchines that I have seen, wear is most pronounced on ml, (and p4 if preserved) and is significantly less evident on m2 and especially m3. m3 and m3, however, are by no means vestigial and must have functioned significantly in mastication. The differing degree of wear was therefore likely accomplished by delayed eruption of m2 and m3. In this way, two functional molars would remain after p4 and ml were expended. A similar situation apparently occurred in certain didelphid marsupials (Fox pers. comm. 1980) and in various other condylarths, in particular those with dentitions suited for crushing and grinding such as Mioclaenus turgidus (AMNH 3154), but is not as evident in condylarths with relatively sectorial dentitions, such as Oxyprimus albertensis (UA 1338 and ROM 12865).

UA 16044 is similar to the type specimen, Anisonchus oligistus (USNM 16192), a dentary fragment with two damaged molars (a maxillary fragment is also part of the type). Gazin (1941) originally described these as ml and m2, but they are more likely m2 and m3 (J. Archibald pers. comm.). A few differences with UA 16044 are evident: an external cingulid is present on the trigonids on USNM 16192 but is entirely lacking on UA 16044; the precingulid extends well onto the lingual surface of the metaconid on USNM 16192 but does not on UA 16044; m3, especially the talonid, is slightly more transverse on USNM 16192.

Discussion: The specimens described above closely resemble corresponding elements of Anisonchus oligistus (known from Purgatory Hill [Van Valen 1978] and Wagonroad [Gazin 1941], both of Puercan age). The differences noted above, however, preclude direct referral

of the Rav W-1 form to that species; assessment of the taxonomic significance of these differences awaits the recovery of a larger sample and a clearer knowledge of variability in the Rav W-1 form.

Van Valen (1978: 64) erected a subgenus, Anisonchus (Mithrandir) on the basis of synapomorphies that include, among others, the interruption of the postcingulum by the postmetaconular crista. This feature is present in UA 16042 and indicates the Rav W-1 species belongs here. Species comprising the subgenus include A. gillianus (Puercan, Nacimiento Formation), A. oligistus and Anisonchus onostus Gazin 1941 (Torrejonian, North Horn Formation). Van Valen suggests that these species, except possibly A. gillianus, form a lineage. I agree with Van Valen that A. gillianus, although closely related, is not a structural or phyletic precursor of the other members (including the Rav W-1 species) of the subgenus. Comparisons of the Rav W-1 species and A. gillianus reveal a mosaic of primitive and derived characters distributed between the two. The lower molars of the Rav W-1 species are clearly less swollen and more elongate (especially m3) than in A. gillianus and are therefore less derived in at least this character state; however, the cristid obliqua meets the trigonid at a point more labial than in A. gillanus, a relatively derived feature.

Family Mioclaenidae Osborn and Earle 1895

Subfamily Mioclaeninae Osborn and Earle 1895

Bubogonia n. gen.

Etymology: Βουβών, Gk. inflamed, swollen & γωνία, Gk., angle, with reference to the enlarged metaconid on the lower molars.

Type species: Bubogonia saskia n. sp.

Diagnosis: As for the type and only species.

Bubogonia saskia n. sp.

(Figure 32; Table 15)

Etymology: sask, reference is to the province of Saskatchewan where the known specimens have been found.

Type specimen: UA 15105, an incomplete right dentary with m2 and m3.

Type locality: NW. 1/4, sect. 23, Tp. 6, R. 24, W. 6, site Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 16030, ?M1; UA 15108, M3; UA 16031-32, m2's.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Diagnosis: Molars similar to Protoselene griphus (Gazin) 1941 and Protoselene opisthacus (Cope) 1882b, but differing as follows: on M3, B. saskia, protocone less compressed anteroposteriorly and more bunodont, mesostyle lacking, parastylar lobe broader and more protruding, internal

Figure 32. Bubogonia saskia n. gen., n. sp., Rav W-1: (a) occlusal view, UA 16030, left ?M1, posterior width 6.90, about X6.5; (b) occlusal view, UA 15108, left M3, posterior width 6.55, about X6.5; (c) occlusal view, m3 length 6.20, about X3; (d) labial, and (e) lingual view, UA 15105 (type), right dentary fragment below anterior alveolus of m2 on labial side 12.00 about X1.5.

a
b

c

e

Table 15. Measurements of the dentition of Bubogonia saskia n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
?M1	L	-	----	----
	Ant-W	-	----	----
	Post-W	1	6.90	----
M3	L	1	5.20	----
	Ant-W	1	7.25	----
	Post-W	1	6.55	----
m2	L	3	5.70-6.10	5.90
	Tri-W	3	4.20-4.70	4.53
	Tal-W	3	4.20-4.80	4.57
m3	L	1	6.20	----
	Tri-W	1	4.05	----
	Tal-W	1	3.70	----

cingulum complete; lower molars with ectocingulid, metaconid proportionately much larger, paraconid not as reduced and not labially shifted, trigonid taller than in P. griphus and P. opisthacus; apices of cusps and crests blunter, talonid basin shallower, entocristid lower and m3 hypoconulid less projecting than in P. opisthacus. Similarities with lower molars of Choeroclaenus turgidunculus (Cope) 1888 also evident, but lower molars of B. saskia larger, less swollen and with less reduced paraconid.

Description: ?M1 and M3. -- A single, fragmentary specimen, UA 16030, likely represents M1, B. saskia. Most of the anterior part of the crown, including the paracone, parastylar lobe and precingulum, is broken away. UA 16030 could not be an M3; unlike UA 15108 (M3), the postcingulum is not interrupted on the posterior wall of the metacone. The posterior width of UA 16030 is greater than the posterior width, but less than the anterior width, of UA 15108; when compared to the upper molars of closely related species, such as Protoselene griphus (formerly Dracoclaenus until Van Valen 1978), UA 16030 more closely resembles M1 than M2. The conules in both UA 16030 and 15108 are well developed; however, the hypocone is weak, taking the form of a small cuspule that is circumferentially much smaller than the conules. Additional cuspules of variable sizes are also present on the pre- and postcingulum; these cingula are lingually continuous on UA 15108 and nearly continuous on UA 16030. The postcingulum terminates labially just short of the postmetaconular crista; the precingulum, though worn on UA 15108, appears to have anastomozed with the preparaconular crista. The external wings of the conules are continuous with the ectocingulum; the internal wings are absent but a small cuspule is present in place of the premetaconular crista on UA 15108. The ectocingulum is continuous on UA 15108 (broken away on UA 16030) and lacks a mesostyle. On both UA 15108 and 16030, a distinctive cruciate

wear surface takes in the opposing walls and intercusp valley of the paracone and metacone; elsewhere on the crown wear is relatively minor except on the parastylar lobe of UA 15108. The enamel is wrinkled on UA 15108, less so on UA 16030.

Similarities are evident between these teeth and the corresponding molars of P. griphus and P. opisthacus but the following differences are noted: on M3, B. saskia, the protocone is more bunodont and is much less anteroposteriorly compressed, a mesostyle (prominent on M3, P. griphus, and P. opisthacus) is entirely lacking, the ectoflexus is relatively deeper, and the parastylar lobe is broader and more protruding; the internal cingulum is complete on M3 and more nearly complete on M1 than in P. griphus and P. opisthacus; M1 is less quadrate lingually.

m2-m3. -- m2 and m3, B. saskia, are subquadrate in outline; the trigonid is relatively high as in oxyclaenines but both the talonid and trigonid cusps are turgid and their apices, blunt. The paraconid is slightly reduced but distinct; however, on m3, it is much less appressed to the metaconid, and in lingual view, the paraconid-metaconid notch is significantly deeper than on m2. The trigonid basin opens anteriorly over the paracristid at the paraconid-protoconid notch. The most striking feature of the lower molars of B. saskia is the relatively tall and massive metaconid that dwarfs the protoconid in both height and volume. The anterior wall of the trigonid of m2 bears a distinct concavity that received the posterior edge of m1; m2 likewise bears this concavity but it does not result in emargination of the outline of the trigonid to the extent on m2. The apices of the paraconid, metaconid and entoconid are co-linear.

The talonid basin of m2 is relatively shallow and is inclined

lingually toward the relatively large talonid notch. On m3, the floor of the talonid forms a shallow V-shaped valley rather than a basin, with the axis of the valley extending from the talonid notch obliquely across the talonid to the relatively deep notch between the hypoconid and hypoconulid. On m2, the hypoconulid and entoconid are partially adnate, and on m3 these cusps are almost completely welded together, forming a thick loph with only a vestige of the intercusp valley remaining. The entoconid on both m2 and m3 is lower than the hypoconid. The hypoconulid on m3 is relatively blunt posteriorly and does not protrude significantly from the body of the talonid. Accessory cuspules appear on the entocristid of m2 in the type but are lacking on UA 16031-32. The ectocingulid is generally complete but can be briefly interrupted at the base of the hypoconulid on m2. The enamel is slightly wrinkled. The depth of the dentary of the type, below the anterior alveolus of m2 on the labial surface, is 12 mm, about twice the length of m2.

m2 and m3, B. saskia, are about the size of corresponding molars in specimens of P. opisthacus at hand (KU 7852, 13997) but differ morphologically in the following ways: the trigonid in B. saskia is relatively higher and less anteroposteriorly compressed; the paraconid is less reduced and is not shifted labially; the metaconid is proportionately much larger; the apices of cusps and crests on both the talonid and trigonid are blunter; the talonid basin is shallower and the entoconid is relatively lower; the hypoconulid of m3 is much less protruding from the body of the talonid and is less pinched labiolingually.

m2, P. griphus (USNM 15773) (m3 has not been described), is more similar to m2, B. saskia, than is m2, P. opisthacus, but differs as follows:

m2, P. griphus, is shorter anteroposteriorly and is relatively more transverse, the paraconid is labially shifted, the metaconid is not as swollen, the trigonid is relatively lower and there is no ectocingulid. Unlike P. opisthacus, the entoconid is low and the talonid basin is shallow as in B. saskia.

Discussion: Bubogonia saskia appears to be a relatively primitive mioclaenid and retains certain features in the lower molars characteristic of primitive oxyclaenines, such as the relatively high trigonid, the relatively unreduced and internally positioned paraconid and the presence of an ectocingulid. Recognition of B. saskia as a mioclaenid is based on the large talonid notch, fusion of the entoconid and hypoconulid and the relatively large metaconid.

According to Van Valen's (1978: fig. 5) provisional phylogeny of the Mioclaenidae, Protoselene is viewed as a primitive member of the subfamily Pleuraspidotheriinae Zittel 1892. This subfamily is characterized, among other features, by the acquisition of selenodonty, by the tendency of the metaconid and entoconid to become the dominant cusps of the lower molars, as well as the development of a pronounced hypocone and mesostyle on the upper molars. These features are already evident or incipiently present in P. opisthacus (less so in P. griphus) and become accentuated in the terminal genus Pleuraspidotherium Lemoine 1878. Van Valen (1978) groups the other members of the Mioclaenidae within the subfamily Mioclaeninae Osborn and Earle 1895; here, the mesostyle is variably present and never pronounced; the metaconid, though generally relatively large, is not as hypertrophied as in the pleuraspidotheriines, and the paraconid becomes reduced but does not shift as far labially; the entoconid remains primitively

low or becomes even more reduced (as in Mioclaenus turgidus Cope 1881); the molars become rounded, bunodont and turgid and the premolars, swollen. The premolars of B. saskia are unknown; however, the molars are turgid and the apices of cusps and crests are relatively rounded, the entoconid is not as high as the hypoconid and the paraconid is not shifted labially. These features suggest B. saskia is affiliated with the mioclaenines, rather than the pleuraspidotheriines; however, similarities with Protoselene, especially P. griphus, indicate B. saskia must be structurally near the progenitor of the Pleuraspidotheriinae.

Among the mioclaenines, B. saskia appears most similar to Choeroclaenus turgidunculus; the talonid of m3 is particularly similar, being posteriorly blunt, unlike m3, P. opisthacus. B. saskia is larger and less derived than C. turgidunculus; the paraconid in B. saskia is less reduced and the molars are not as swollen. In known parts of the dentition, B. saskia may be viewed as a reasonable structural antecedent of C. turgidunculus and phyletically belongs near the base of the Choeroclaenus - Mioclaenus lineage, although B. saskia is itself not necessarily the progenitor of that lineage.

Van Valen (1978: fig. 5) suggested that, among known mioclaenids, Promioclaenus Trouessart 1904 most closely approaches the basal members from which other species in the family were derived. Oxyclaenine-like features of B. saskia, such as the relatively high trigonid, the relatively less reduced paraconid and less reduced m3, do not appear derivable from known species of Promioclaenus. B. saskia as well as the Choeroclaenus - Mioclaenus lineage and the pleuraspidotheriines were likely derived from a common ancestor with Promioclaenus and its derivatives, that was more oxyclaenine-like than known species of

Promioclaenus but more mioclaenid-like than known species of oxyclaenines. As Van Valen suggested (1978: fig. 2 and 5) Protungulatum, rather than Oxyprimus, appears to represent an appropriate ultimately ancestral state (although not an immediate one) for the mioclaenids; the relatively large talonid notch characteristic of most mioclaenids is better developed in Protungulatum than in Oxyprimus.

Van Valen (1978: pl. 8) figured a maxillary fragment with M2 (from the Hemithlaeus-zone of the Naciemiento Formation, New Mexico) upon which he named a new species of Protoselene, Protoselene bombadili. This species is much smaller than B. saskia but the m2 lacks a mesostyle as does UA 15108 (M3, B. saskia) as well as a hypocone (hypocone only incipiently developed in known upper molars of B. saskia). P. bombadili may possibly prove to be a species of Bubogonia but until lower molars of this species are described relationship with B. saskia cannot be ascertained.

?Litaletes Simpson 1935a

?Litaletes sp.

(Figure 33)

Referred specimens: 15140, m3.

Locality: Rav W-1, Ravenscrag Formation, Saskatchewan.

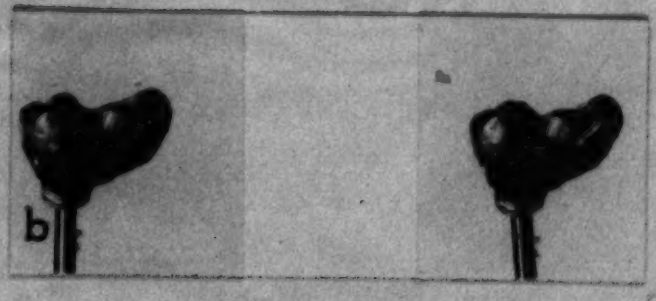
Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description and discussion: A single m3 (UA 15140) appears to represent a small mioclaenine. Measurements of UA 15140 are as follows: L = 5.20; Tri-W = 3.60; Tal-W = 3.15. The crown is very bunodont and the cusps are swollen. The paraconid is lingually positioned and is as tall and circumferentially as large as the metaconid. The talonid basin is shallow and the entoconid is completely reduced and consists of nothing more than a crest that is fused with the hypoconulid. The entocristid extends across the talonid notch. The crown is rounded, the enamel is smooth and there are no cingula except for a vestige of the precingulid and a remnant of the ectocingulid between the hypoconid and hypoconulid.

UA 15140 is most similar to the m3 of the early Torrejonian species Litaletes sternbergi (USNM 15721, formerly the type of Ellipsodon shepherdi until Van Valen 1978: 59) among known mioclaenines but is larger and less derived in certain character states: the paraconid is much less reduced and appressed to the metaconid; and the talonid is relatively larger. A vestige of the entoconid is, however, present on m3, USNM 15721, but the entoconid is absent in UA 15140; in this feature, the latter is the more derived.

Figure 33. ?Litaletes sp., Rav W-1: (a) occlusal, and (b) labial view, UA 15140, left m3, length 5.2, about X4.5.

a


b

Similarities are also evident with various Torrejonian species of Promioclaenus, such as Promioclaenus acolytus (Cope) 1882b, but as with L. sternbergi, the paraconid and talonid are larger in UA 15140, but the entoconid is smaller. m3 of the Puercan species of Promioclaenus, including Promioclaenus vanderhoofi (formerly Tiznatzinia Simpson 1936 until Van Valen 1978: 59), and Promioclaenus wilsoni Van Valen 1978, has not been described nor figured. The m1 and m2 of the type specimen of P. vanderhoofi have been described and figured, and the paraconid on these teeth (and by extrapolation on m3 as well) is clearly smaller than on UA 15140. The only other small mioclaenine, Bomburia priscus (Matthew) 1937, is even less like UA 15140 in the structure of m3, having a greatly reduced talonid and a reduced and lingually shifted paraconid, although the entoconid is entirely absent, as on UA 15140.

UA 15140 undoubtedly represents a new species of mioclaenine whose taxonomic relationships are at this time unclear and will remain so until additional material is recovered. I have tentatively referred UA 15140 to Litaletes sp. simply to point out the general phenetic similarities of this specimen with m3, L. sternbergi, although insufficient material exists to confidently establish a phyletic relationship with species of that lineage.

Family Hyopsodontidae Trouessart 1897

Subfamily Hyopsodontinae Trouessart 1897

Litomylus Simpson 1935b

Litomylus orthronepius n. sp.

(Figure 34; Table 16)

Etymology: ὄρθρος, Gk. morning & νήπιος, Gk. child, babe; from its geologically early occurrence and its basal position in the lineage.

Type specimen: UA 15122, m2.

Type locality: NW. 1/4, sect. 23, Tp. 6, R. 24, W. 6; Loc. Rav W-1, about 3.5 km WNW of the village of Ravenscrag, Saskatchewan.

Referred specimens: UA 16033-34, M1's; UA 16037, ?M1; UA 15121, 16135-36 (total: 3), M2's; UA 16038, m1; UA 15123, m3; UA 16039-40, mX's.

Diagnosis: Molars smaller than in Oxyprimus erikseni Van Valen 1978, paraconid of m2 and m3 more appressed to metaconid, cusps of lower molars more swollen, trigonid of m3 less steep postvallid, conules and hypocone of M2 better developed; m2 less transverse, m3 more elongate, hypoconulid and entoconid of m3 less adnate, entocristid on m2 and m3, less steeply inclined, paraconid less appressed to metaconid, cusps less swollen than in Litomylus perissum (Gazin) 1941.

Description: M1-M2. -- Two very poorly preserved specimens (UA 16033-34) are recognized as M1, L. orthronepius. Both specimens exhibit extensive postmortem dissolution of the enamel so that few details remain. The association of these specimens with the other dental elements referred to L. orthronepius, is based primarily on the

Figure 34. Litomylus orthronepius n. sp., Rav W-1: (a) occlusal view, UA 16034, left M1, posterior width 3.75, about X9; (b) occlusal view, UA 15121, right M2, posterior width 4.40, about X9; (c) occlusal, and (d) labial view, UA 15123, left m1, length 3.05, about X9; (e) labial, and (f) occlusal view, UA 15123, left m3, length 3.65, about X9; (g) occlusal, (h) lingual, and (i) labial view, UA 15122 (type), right m2, length 3.10, about X9.

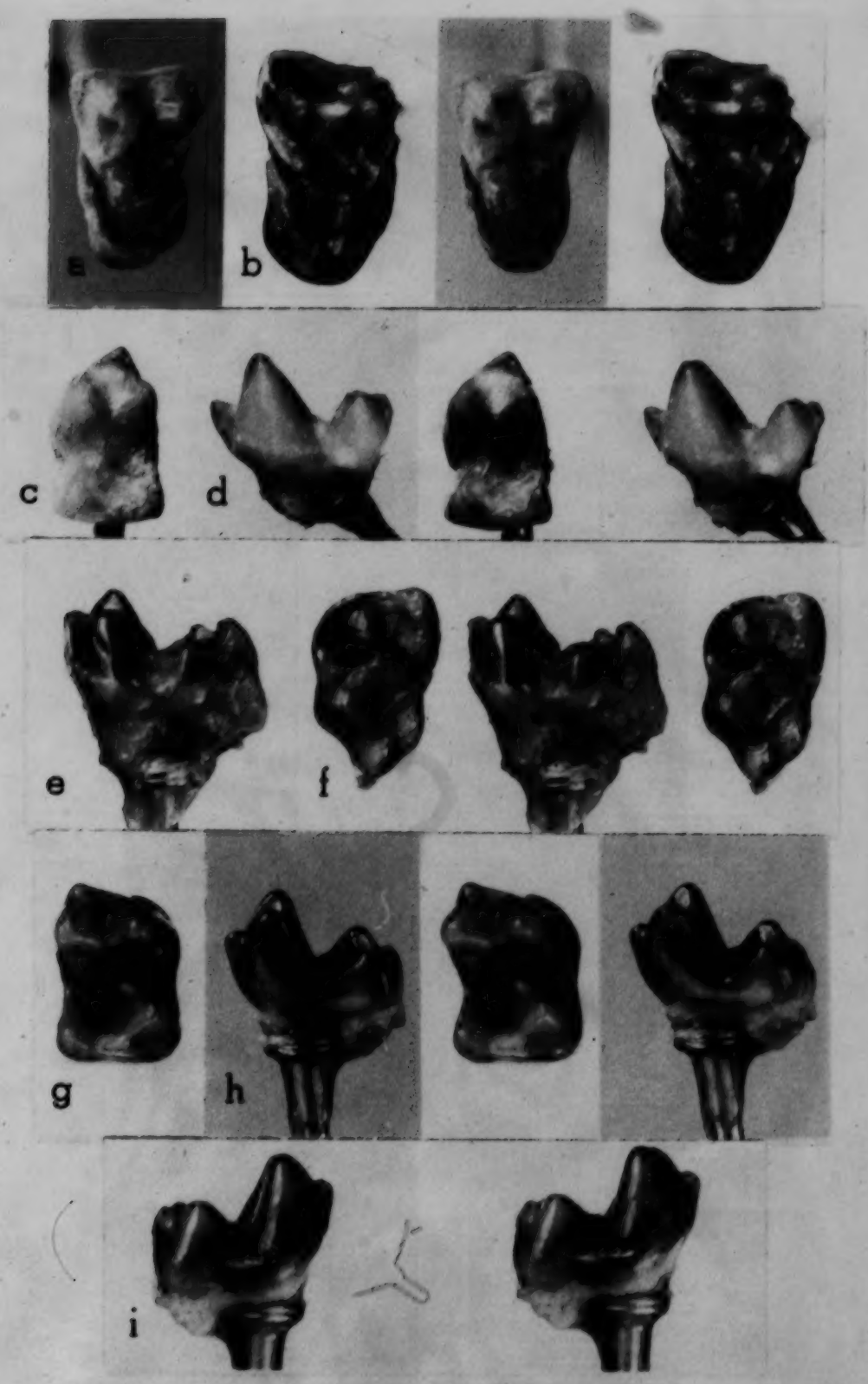

a
b
c
d
e
f
g
h
i

Table 16. Measurements of the dentition of Litomylus orthronepius n. sp., Loc. Rav W-1.

Element	Dimension	N	OR	M
M1	L	1	2.80 (est.)	-
	Ant-W	1	3.70	-
	Post-W	1	3.75	-
M2	L	1	3.05	-
	Ant-W	1	4.50	-
	Post-W	2	4.30-4.40	4.35
m1	L	1	3.05	-
	Tri-W	1	1.95	-
	Tal-W	1	2.10	-
m2	L	1	3.10	-
	Tri-W	1	2.20	-
	Tal-W	1	2.25	-
m3	L	1	3.65	-
	Tri-W	1	2.30	-
	Tal-W	1	2.05	-

appropriateness of size and outline and the fact that these teeth are much too small to be confused with any other condylarth in the Rav W-1 assemblage. Another specimen, UA 16037, may also be an M1, but it is split transversely down the middle with the entire anterior half missing; the remaining features are like those of M2 but the crown is less transverse (Post-W = 3.95).

M2 is known from three specimens although each is either damaged or worn. The crown is relatively more transverse than in M1 and the ectoflexus is deeper. The metacone and paracone are of equal height, although the former appears distinctly wider at its base when viewed labially. The conules and the external wings of the conules are strong; the internal wings are variably developed. The parastylar lobe projects anteriorly from the body of the crown (UA 16035). The pre- and postcingula are not continuous across the lingual face of the protocone; the width of the gap separating them is variable (relatively narrow in UA 16036, wider in UA 15121). A hypocone is invariably present; its height and circumference are slightly less than that of the conules.

The upper molars have not been described for the hitherto oldest member of the genus, Litomylus perissum (formerly Oxytomodon Gazin 1941 until Van Valen 1978) from the early Torrejonian of Utah; however, in comparison to later species, such as Litomylus dissentaneus Simpson 1935, the stylar shelf on M2, L. orthronepius is significantly wider, the apices of cusps and crests are more acute, the cusps are less inflated and the crown is more transverse; all of these are primitive character states and closely approach corresponding characters on M2 of the Lancian and early Mantuan (Archibald pers. comm.) oxyclaenine, Oxyprimus erikseni. Few differences exist between the M1 and M2 of

O. erikseni (UCMP 116513 [M2] and figures, Archibald 1977, UCMP Loc. V74111, basal Tullock Formation) and L. orthronepius except that in the latter, the crowns are smaller and the conules and especially the hypocone, are better developed. In labial view the paracone-metacone notch is relatively deeper and the paracone is narrower at its base on M2, L. orthronepius (UA 15121), than on M2, O. erikseni (UCMP 116513). Similarities are evident with M2, Haplaletes andakupensis Van Valen 1978 (Puercan), but M2, L. orthronepius is, as compared to Van Valen's (1978: 60, 76) figure and measurements, relatively more transverse and the ectoflexus is shallower. Other elements of the dentition of H. andakupensis have been neither figured nor adequately described; thus further comparisons cannot be made at present.

The known upper molars of L. orthronepius are structurally intermediate, particularly in the development of the hypocone and conules, between those of O. erikseni and those of later species in the genus, although more similar to the former.

m1-m3. -- Each of the molar positions is represented by a single complete specimen (UA 16038 is damaged at the base of the talonid but all of the cusps are intact). Two fragmentary trigonids (UA 16039-40) may be either m2's or m3's. The molars are of a simple tritubercular-sectorial pattern with a relatively high trigonid. The paraconid of m2 and m3 is somewhat reduced and appressed to the metaconid but remains distinct and internally positioned. On m1 the paraconid is well separated from the metaconid and the trigonid cusps are less swollen than on m2 and m3. The talonid basin is relatively deep and the talonid notch is closed except for a minute gap on m3. On m1 and m2 the hypoconulid is the lowest and least distinct of the talonid cusps;

the hypoconid is the tallest and most massive. The external cingulum is weak on all the molars and is discontinuous across the labial face of the hypoconid (and protoconid on m1).

The lower molars of L. orthronepius are structurally intermediate between those of Oxyprimus erikseni and those of the hitherto oldest known species of Litomylus, Litomylus perissum. Comparisons of the lower molars of L. orthronepius with the type L. perissum (USNM 16183, a partial dentary with m2-m3 [cast]) and lower molars pertaining to O. erikseni (UCMP 116500 [m2], 116510 [m3] and figures in Van Valen 1978, Archibald 1977) indicate that observed differences are primarily quantitative rather than qualitative. The paraconid on m2 and m3 is less appressed to the metaconid, the trigonid basin is less constricted and the cusps of the trigonid and talonid are less swollen than in L. perissum but more so than in O. erikseni. The molars are smaller than in O. erikseni; m2 is of similar length to that of L. perissum, but is relatively less transverse; m3 appears to be more elongate than in L. perissum (m3 broken in type) and of similar width. The hypoconulid is mostly broken away on m3 of the type, L. perissum, but a remnant indicates that it was much more adnate with the entoconid than in L. orthronepius or O. erikseni. The angle formed by the entocristid and the posterior wall of the talonid on m3 and m3 is much less acute in L. orthronepius than in L. perissum, but is not noticeably different than in O. erikseni. The trigonid is steeper postvallid on m3, O. erikseni, than in either L. orthronepius or L. perissum.

Discussion: Rigby (1980) has removed Litomylus (except Litomylus perissum, which he recognized under its former name Oxytomodon perissum) and its ally Haplomylus Matthew 1915 from the Hyopsodontidae and placed

them within the Order Insectivora, Family Adapisoricidae, claiming they are most closely related to Mckennatherium rather than to other undoubted hyopsodontids. He bases this revision on various features of Litomylus, such as the formation of the medial paraconid (s.l.), which he believes is achieved in a different manner than in other hyopsodontids, and similarities of P4, p4, Litomylus, with that in certain species of Mckennatherium. Last premolars are unknown for either L. orthronepius or L. perissum. Evaluation of Rigby's suggestions concerning the taxonomic position of Litomylus is beyond the scope of this paper and the specimens at hand; however, if he proves correct, L. orthronepius will be transferred to Oxytomodon and will remain in the Hyopsodontidae.

On the basis of known elements of the dentition, L. orthronepius appears to be a very primitive hyopsodontid and is a reasonable structural and possibly phyletic intermediate between O. erikseni and L. perissum and perhaps other hyopsodontids, as well.

Part II: Long Fall

Class Mammalia

Subclass Prototheria

Infraclass Allotheria

Order Multituberculata

Suborder and Family *incertae sedis*

Cimexomys Sloan and Van Valen 1965

Cimexomys cf. *C. hausoi* Archibald (in press)

(Figure 35)

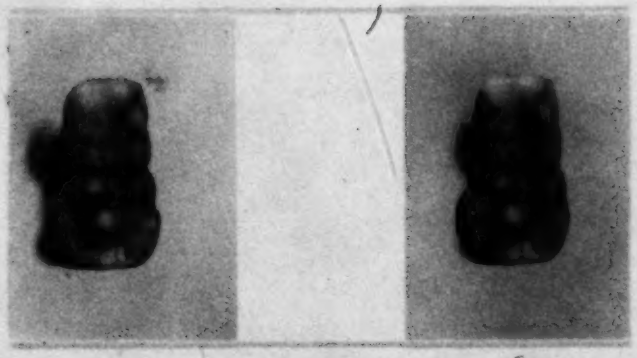
Referred specimens: UA 16061, M1.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Puercan, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Discussion: UA 16061 (L = 3.20, W = 1.90) appears to be an M1 of a species of *Cimexomys*. It is much larger than M1, *Cimexomys minor* Sloan and Van Valen 1965, and more cuspidate (cusp formula = 5:6:R) than the M1 of known species of *Paracimexomys* Archibald (in press). The size, cusp ratio and morphology of UA 16061 matches that of *Cimexomys hausoi* Archibald (in press), (basal Tullock Formation) as given in Archibald 1977. However, in view of the fact that the Rav W-1 species is thus far known from only a single specimen, and that specimen is itself worn, the identification of the Long Fall species cannot be established with certainty.

Figure 35. Cimexomys cf. C. hausoi, Long Fall: occlusal view, UA 16061, left M1, length 3.20, about X9.



Suborder Ptilodontoidea

Family Neoplagiaulacidae Ameghino 1890

Mesodma Jepsen 1940

Mesodma thompsoni Clemens 1963

(Figure 36; Table 17)

Referred specimens: UA 16062-65 (total: 4), p4's; UA 16066-67, m2's; UA 16068, M1; UA 16069, M2.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution.

Discussion: On the basis of qualitative features, the teeth under consideration undoubtedly pertain to some (or perhaps more than one) species of Mesodma. The distinction of various species of Mesodma is primarily a statistical problem (see Novacek and Clemens 1977; Archibald 1977); consequently, the recognition of the Long Fall species as conspecific with any named species of Mesodma is made difficult by the small sample size at hand. The largest p4 (UA 16062) in the Long Fall sample exceeds that of any p4 of Mesodma formosa (Marsh) 1889 from the Lull 2 locality of the Lance (on basis of comparisons with measurements given by Novacek and Clemens 1977: 704) and all the p4's exceed the mean length of p4, M. formosa, in that sample, but are less than that of M. thompsoni (Lull 2, Lance, Novacek and Clemens 1977). Novacek and Clemens found that the sample of Mesodma from the Bug Creek Anthills was intermediate in size between M. formosa and M. thompsoni but they did not name a new species; they did suggest the Bug Creek Anthills sample was more similar to M. thompsoni than to M. formosa and possibly a subspecies of the former. The p4's recovered from Long Fall,

Figure 36. Mesodma thompsoni, Long Fall: (a) labial, and (b) lingual view, UA 16062, right p4, length 4.00, about X3.60.

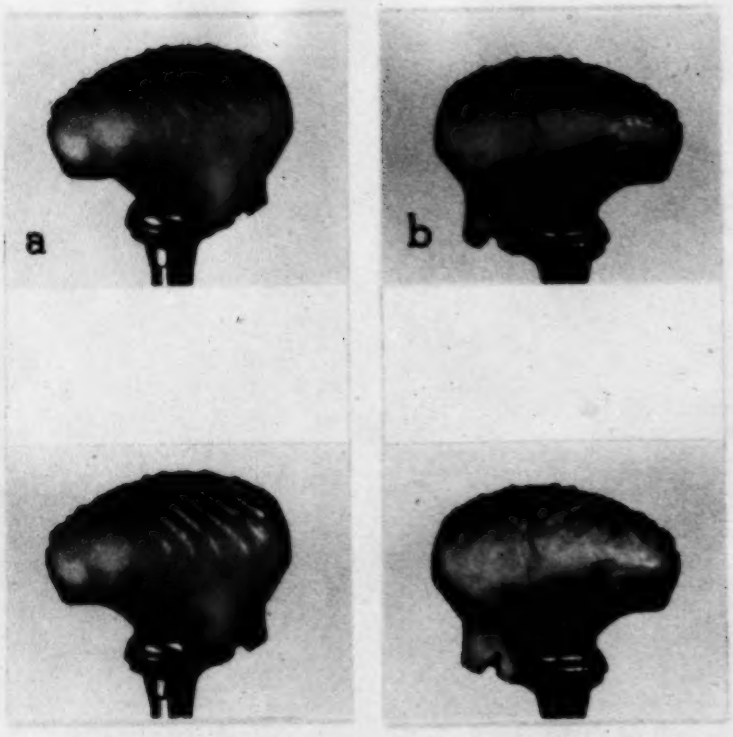


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Table 17. Measurements of the dentition of Mesodma thompsoni, Loc. Long Fall.

Element	Dimension	N	OR	M
p4	L	4	3.45-4.00	3.75
	L_1	1	1.70	----
	h	1	2.00	----
m2	L	2	1.45-1.55	1.50
	W	2	1.15-1.30	1.23
M1	L	1	3.15	----
	W	1	1.40	----
M2	L	1	1.60	----
	W	1	1.50	----

although of limited number, are, statistically, most similar to the Bug Creek Anthills sample. Other elements in the Long Fall sample referred here are indistinguishable from corresponding elements of Mesodma from Bug Creek Anthills.

Family Taeniolabidae Granger and Simpson 1929

Catopsalis Cope 1882a

Catopsalis cf. C. foliatus Cope 1882a

(Figure 37; Table 18)

Referred specimens: UA 16056, I1; UA 15057, i1, UA 16058, m1.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan; (?) pre-Mantuan - post-Lancian Tullock Formation, Garfield County, Montana (Archibald, pers. comm.).

Description and discussion: The specimens recovered from Long Fall referable to Catopsalis are intermediate in size between the Lancian species Catopsalis joyneri Sloan and Van Valen 1965 and the Puercan species (Van Valen and Sloan 1966) C. foliatus, although closer to the latter. Archibald (1977) described a fragmentary M1 that he referred to Catopsalis sp. from the Hell's Hollow local fauna (basal Tullock Formation); it is likewise intermediate in size between C. joyneri and C. foliatus. A new undescribed similarly-sized species of Catopsalis, apparently conspecific with the Hell's Hollow species (and possibly with the Long Fall species) is present at the Alexander locality (Puercan, Denver Formation [Middleton, in progress], J. Archibald 1980, pers. comm.) and is represented by well preserved material. Therefore, detailed description of the Long Fall specimens is deferred until the Alexander material is described.

The cusp formula of UA 16058 (m1) is 7:4; the posterior cusp of the external row is partially broken away.

Figure 37. Catopsalis cf. C. foliatus, Long Fall: (a) labial view, UA 16056, left I1, maximum diameter 3.5, about X9; (b) ventral view, UA 15057, left i1, maximum diameter 4.00, about X5; (c) occlusal, (d) labial, and (e) lingual view, UA 16058, left m1, length 9.70, about X5.

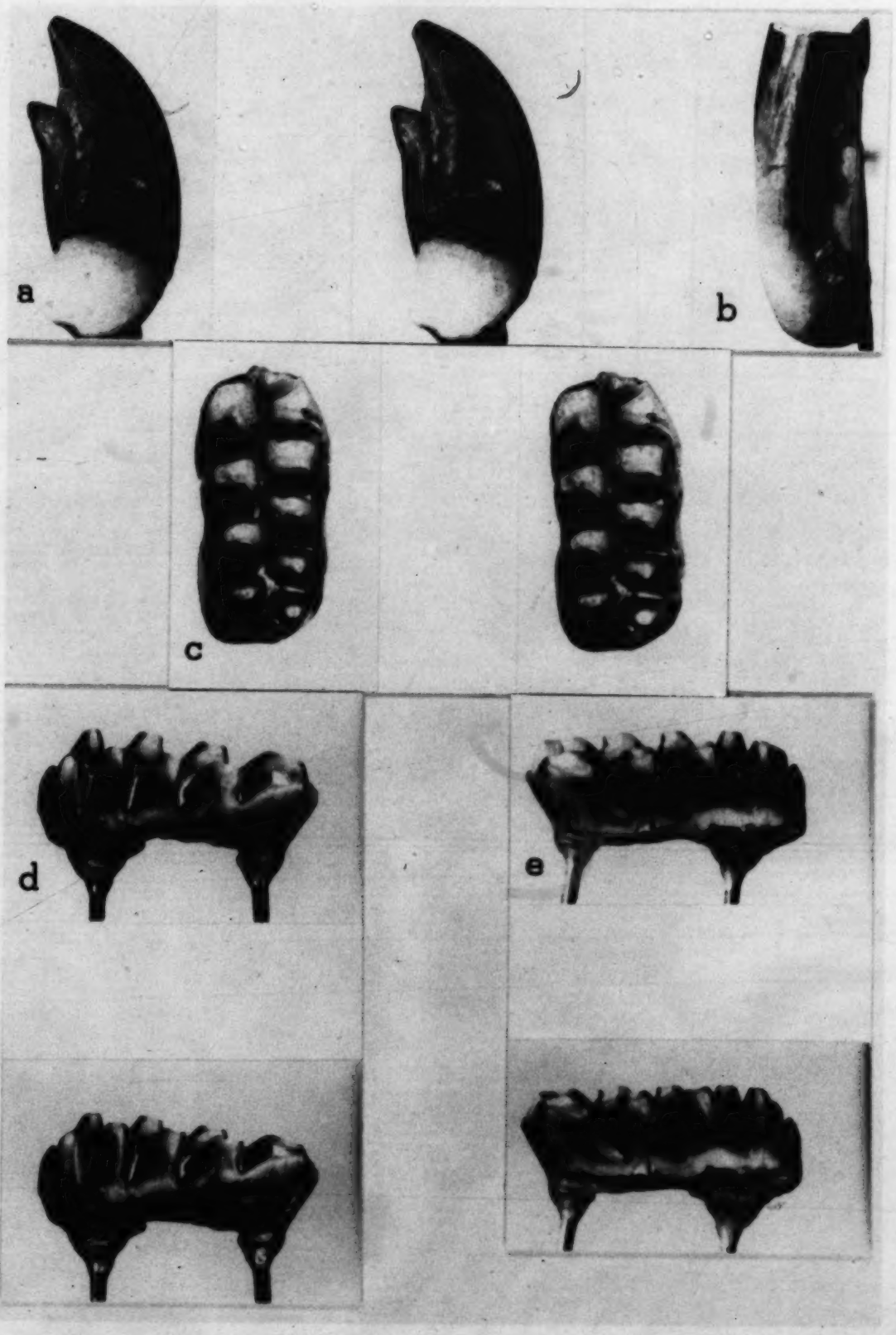
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Table 18. Measurements of the dentition of *Catopsalis* cf. *C. foliatus*, Loc. Long Fall.

Element	Dimension	N	OR	M
I1	Max-D	1	3.50	-
	Min-D	1	2.10	-
i1	Max-D	1	4.00	-
	Min-D	1	3.40	-
m1	L	1	9.70	-
	W	1	4.65	-

Subclass Theria

Infraclass Metatheria

Superorder Marsupialia

Order Marsupicarnivora

Family Pediomyidae (Simpson) 1927

Pediomys Marsh 1889

Pediomys elegans Marsh 1889

(Figure 38; Table 19)

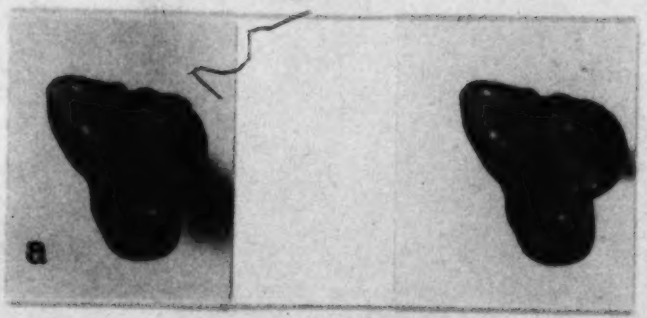
Referred specimens: UA 16060, M2; UA 16059, mX.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian: Lance Formation, Niobrara County, Wyoming; Hell Creek Formation, Garfield and McCone Counties, Montana; Scollard Formation, near Trochu, Alberta; Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Discussion: An M2 (UA 16060) and an isolated talonid (UA 16059), probably of an m2 or m3, have been recovered from Long Fall that pertain to P. elegans. The dentition of P. elegans has been described in detail by Clemens (1966), and the teeth in the present collection agree in all particulars.

Figure 38. Pediomys elegans, Long Fall: (a) occlusal view, UA 16060, left M2, length 2.00, about X10; (b) occlusal view, UA 16059, right mX, talonid width 1.65, about X10.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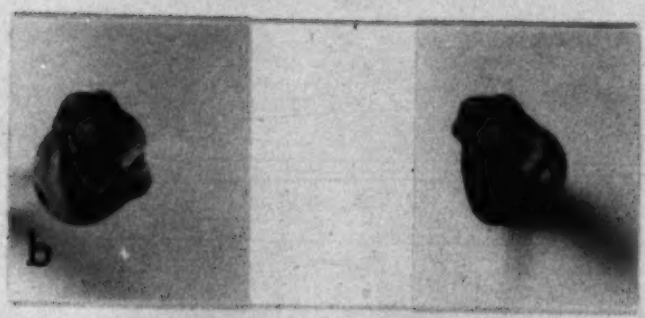
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Table 19. Measurements of the dentition of *Pediomys elegans*, Loc. Long Fall.

Element	Dimension	N	OR	M
M2	L	1	2.00	-
	Ant-W	1	2.70	-
	Post-W	1	2.25	-
mX	L	-	----	-
	Tri-W	-	----	-
	Tal-W	1	1.65	-

Infraclass Eutheria *incertae sedis*

Family Palaeoryctidae (Winge) 1917

Procerberus Sloan and Van Valen 1965

Procerberus cf. *P. formicarum* Sloan and Van Valen 1965

(Figure 39)

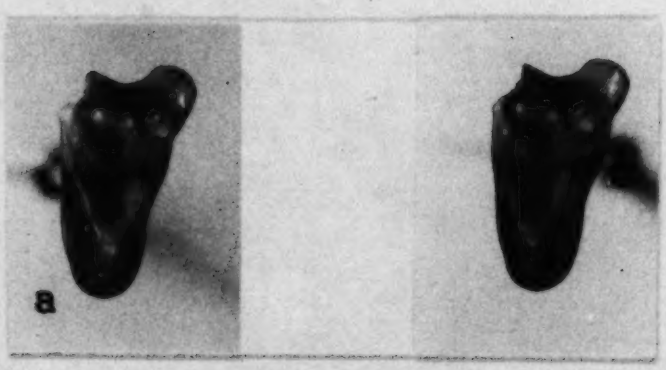
Referred specimens: UA 16075, M2; UA 16074, M3.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Discussion: Two damaged molars recovered from Long Fall are indistinguishable from corresponding teeth of *Procerberus formicarum*. Sloan and Van Valen (1965) and Lillegraven (1969) have adequately described the dentition of *P. formicarum*. The specimens are broken in such a way that only the posterior width of UA 16075 (M2) can be measured (Post-W = 3.8). The posterior width of UA 16075 (M2) falls at the high end of the range of variation of this dimension of M2, *P. formicarum* (as given by Archibald 1977: 350) and UA 16074 (M3) is larger than all M3's of *P. formicarum* at hand (UA 6706-9 [total: 4]). In view of a possible size discrepancy between *P. formicarum* and the Long Fall form I hesitate to regard these as conspecific until a larger sample of the latter is acquired.

Figure 39. Procerberus cf. P. formicarum, Long Fall: (a) occlusal view, UA 16075, left M2, posterior width 3.80, about X9; (b) occlusal view, UA 16074, left M3, about X9.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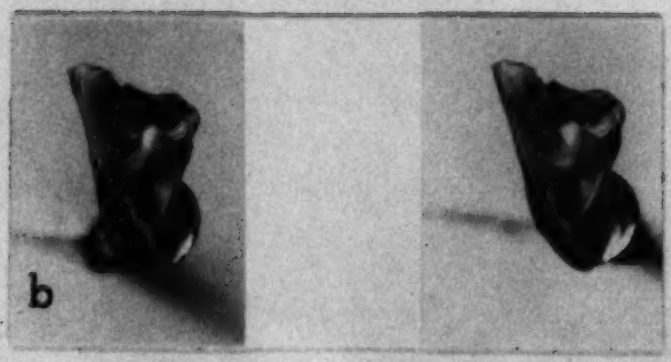
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Order Condylarthra

Family Arctocyonidae Giebel 1855

Subfamily Oxyclaeninae Scott 1892

Protungulatum Sloan and Van Valen 1965

Protungulatum cf. P. donnae Sloan and Van Valen 1965

(Figure 40; Table 20)

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Referred specimens: UA 16049, M2; UA 16050, m2; UA 15149, 16051; m3's.

Known stratigraphic and geographic distribution: Lancian, Long Fall, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: Quantitative comparisons of these specimens with Protungulatum donnae were based on measurements of P. donnae in the UCMP collection provided by J. Archibald (1977: 672).

M2. -- A single specimen, UA 16049, consists of the lingual half of an upper molar that is almost indistinguishable from the corresponding portion of M2, P. donnae. The hypocone, however, is less well developed than on the thirteen M2's referable to P. donnae (BCA) in the UA collection and is less well developed than on the fragmentary M2, referred to Protungulatum cf. P. donnae, recovered from the Frenchman - 1 locality (Johnston 1980) near Long Fall.

m2. -- A single m2, UA 16050, is extensively worn but is of the same size and general structure as m2, P. donnae. The talonid, however, appears slightly longer anteroposteriorly than in specimens of P. donnae at hand.

m3. -- Two m3's (UA 15149, 16051) are similar to m3, P. donnae.

Figure 40. Protungulatum cf. P. donnae, Long Fall: (a) occlusal view, UA 16049, right M2, about X7; (b) occlusal, and (c) labial view, UA 16050, left m2, length 4.15, about X5; (d) occlusal view, UA 16051, left m3, length 4.10, about X7.

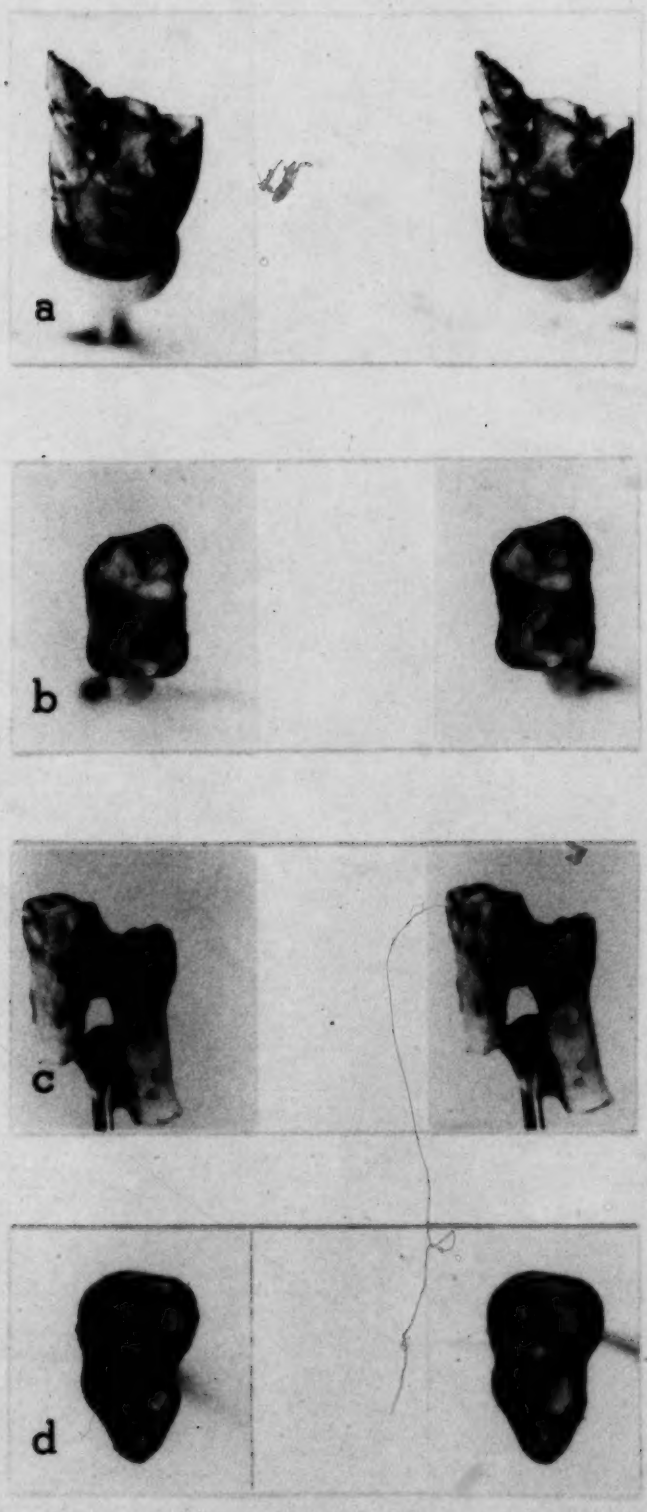
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Table 20. Measurements of the dentition of Protungulatum cf. P. donnae, Loc. Long Fall.

Element	Dimension	N	OR	M
m2	L	1	4.15	-
	Tri-W	1	3.20 (est.)	-
	Tal-W	1	2.95	
m3	L	2	4.10-4.60	4.30
	Tri-W	1	2.60	-
	Tal-W	1	2.10	-

The enamel of UA 15149 is dissolved away labially but the remaining features, as well as the length of the crown, are like those of m3, P. donnae. UA 16051, however, is smaller than most specimens of m3, P. donnae, in the UCMP and UA collection, and the paraconid appears slightly smaller, more appressed to the metaconid, and slightly shifted labially.

Discussion: The sample described above is too small and most specimens too fragmentary to ascertain whether the noted differences with corresponding specimens of P. donnae are of taxonomic significance. Nor is it clear whether the sample comprises only a single species.

?Oxyprimus Van Valen 1978

?Oxyprimus sp.

(Figure 41)

Referred specimens: UA 16053, mX.

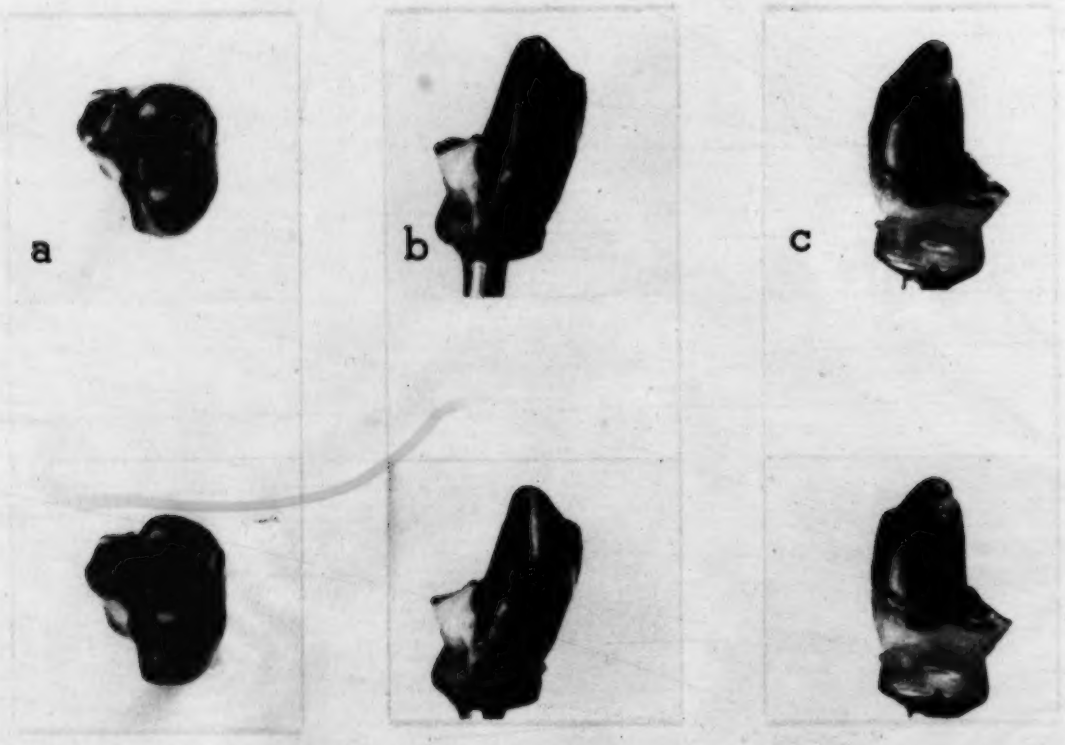
Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description and discussion: UA 16053, an isolated trigonid of unknown positional identity, is 2.70 mm wide. The protoconid and metaconid are of subequal height and circumference; the paraconid, however, is greatly reduced and is appressed to the metaconid. The position of the paraconid is more labial than in the lower molars of Protungulatum donnae but is still lingual to the anteroposterior midline of the crown. A large interdental facet occurs on the anterior wall of the trigonid that has obliterated all but a vestige of the precingulum. An ectocingulum is lacking on the labial wall of the protoconid. The trigonid is anteroposteriorly compressed and the posterior wall is flat and steeply inclined. The anterior extent of the entocristid is present on a remnant of the talonid basin and reveals that the talonid notch was closed.

UA 16053 is probably an m2 or m3 indicated by the appressed condition of the paraconid. The width of UA 16053 falls in the range of trigonid width of m2, Oxyprimus erikseni Van Valen 1978 (on basis of measurements in Archibald 1977: 366), and the form of UA 16053 is similar to the molar trigonid, of that species. A few major differences however, are evident: the paraconid of UA 16053 is much more reduced

Figure 41. ?Oxyprimus sp., Long Fall: (a) occlusal, (b) labial, and (c) lingual view, UA 16053, right mX, trigonid width 2.70, about X8.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and appressed to the metaconid than in O. erikseni and the precingulum, unlike that in O. erikseni, is almost completely absent. These character states are highly derived as compared to other known Lancian condylarths and are rather unanticipated in a condylarth of this age. In O. erikseni, reduction of the paraconid and cingula are incipiently present (Archibald 1977); these trends, although hypertrophied in the Long Fall species, indicate that the relationship of the Long Fall species lies with Oxyprimus rather than with Protungulatum; however, the derived state of UA 16053 indicates the species represented may ultimately require generic distinction.

Subfamily Loxolophinae Van Valen 1978

Ragnarok Van Valen 1978

Ragnarok sp.

(Figure 42)

Referred specimens: UA 16052, m3.

Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

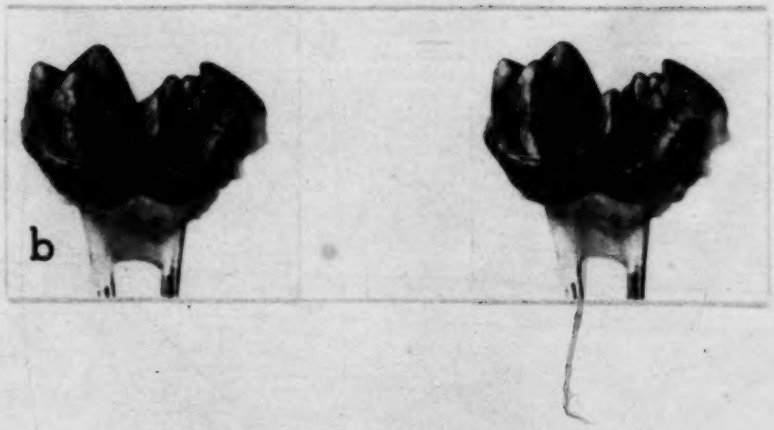
Known stratigraphic and geographic distribution: Lancian, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: UA 16052 (M3) is unworn and well preserved. Measurements are as follows: L = 7.05; Tri-W = 4.55; Tal-W = 3.90. The trigonid cusps are swollen but distinct. The paraconid is unreduced, lingually placed, and well offset from the metaconid. The talonid is much narrower than the trigonid and is relatively deeply basined. A large accessory cuspule, nearly as large as the entoconid, occurs between the entoconid and hypoconulid. The hypoconid is narrow anteroposteriorly and is separated from the hypoconulid by a deep embayment. The entocristid is reduced leaving a large talonid notch. The crown is bordered labially by a thick continuous ectocingulid. A cuspule is present on the ectocingulid at the hypoflexid, and rugae occur at the posterior extent of the ectocingulid and to a lesser extent in the talonid basin.

Discussion: Four species of Ragnarok have been described to date: Ragnarok harbichti Van Valen 1978 (Lancian, Harbict Hill, Hell Creek Formation, Montana [Van Valen 1978]); Ragnarok engdahli Archibald (in press), (Pre-Mantuan - post-Lancian, Hell's Hollow local fauna, Tullock Formation, Montana [J. Archibald, pers. comm.]); Ragnarok nordicum

Figure 42. Ragnarok sp., Long Fall: (a) occlusal, (b) labial, and (c) lingual view, UA 16052, left m3, length 7.05, about X5.

a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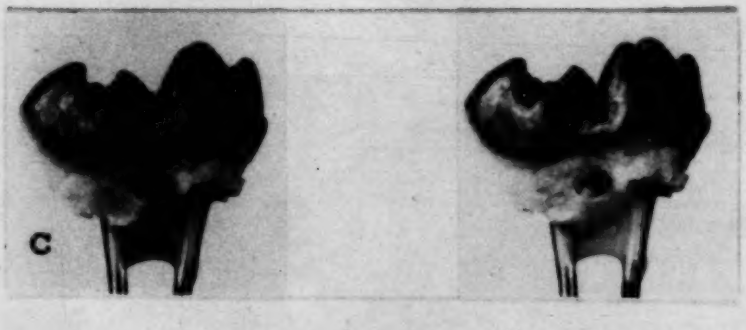

c

(Jepsen) 1930 (pre-Mantuan - post-Lancian, McKeever Ranch I, Tullock Formation, Montana [J. Archibald, pers. comm.]) and Mantuan, Mantua Lentil, Polecat Bench Formation, Wyoming, [Jepsen 1930]; and Ragnarok wovokae Van Valen 1978 (Mantuan, Leidy Quarry, Polecat Bench Formation, Wyoming).

UA 16052 appears to be larger than m3, R. harbichti (by extrapolation from the photograph in Van Valen 1978:75), the trigonid and talonid cusps less bulbous and the ectocingulid broader. UA 16052 is much larger than m3, R. engdahli, according to Archibald's (1977: 405) measurements. m3, R. nordicum, appears close to UA 16052 in size (on the basis of trigonid width of m3, LACM 112902, Archibald 1977: 399). Neither m3 nor any other part of the lower dentition has been described for R. wovokae although Van Valen (1978) states that this species is about the size of R. nordicum. UA 16052 appears morphologically most similar to m3, R. nordicum (as figured in Van Valen 1978: pl. 3), but adequate measurements and description of the m3 of this is lacking in the literature; the sample from Long Fall is too small to provide a more refined identification of the Long Fall species for the present.

Family Periptychidae Cope 1882c

Subfamily Anisonchinae Osborn and Earle 1895

?Earendil Van Valen 1978

?Earendil sp.

(Figure 43)

Referred specimens: UA 16054, M1; UA 16055, M3.

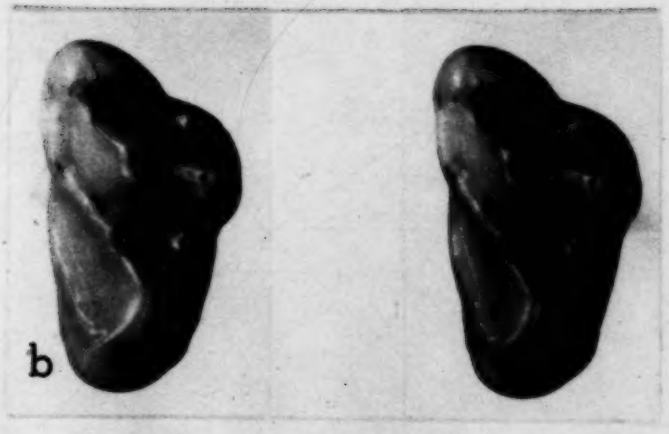
Locality: Long Fall, Ravenscrag Formation, Saskatchewan.

Known stratigraphic and geographic distribution: Lancian, Ravenscrag Formation, near village of Ravenscrag, Saskatchewan.

Description: An M1 (UA 16054) and an M3 (UA 16055, L = 3.70; Ant-W = 5.90; Post-W = 5.00) have been recovered from Long Fall that represent a primitive anisonchine probably referable to Earendil. UA 16054 (M1) is somewhat worn and the corners of the parastylar and metastylar lobes are chipped off precluding conventional measurements. The transverse diameter, from the lingual apex of the ectoflexus to the lingual margin of the protocone, is the same as the posterior width of UA 16055. The stylar shelf of UA 16054 is relatively broad as compared to that of more derived anisonchines, such as Anisonchus oligistus, and the ectoflexus is deeper and V-shaped. A mesostyle is not present but the ectocingulum is raised at that position. The hypocone is no larger than in the primitive oxyclaenine, Protungulatum donnae although its base is swollen lingually. The conules are small; the metaconule is offset posteriorly from the body of the protoconid. As is characteristic of anisonchines, the protocone is displaced labially and the lingual face of the protocone is long and shallowly inclined. The precingulum does not extend as far lingually as the postcingulum

Figure 43. ?Earendil sp. (a) occlusal view, UA 16054, right M2, about X9; (b) occlusal, UA 16055, left M3, anterior width 5.90, about X9.

a


b

and bulges at its lingual extent, suggesting an incipient protostyle. Neither the pre- nor postcingulum are confluent with the external wings of the conules.

UA 16055 (M3) is like UA 16054 in the features described except that the hypocone is lacking, there is no incipient protostyle, a small mesostyle is present, the metaconule is less offset from the protocone and the metastylar lobe is reduced.

UA 16054-55 appear to be very similar in size and architecture to corresponding teeth in the Mantuan species Earendil undomiel Van Valen 1978 and Mimatuta minuial Van Valen 1978 (both known from Mantua Lentil, Polecat Bench Formation, Wyoming) as figured in Van Valen 1978: pl. 7. The lingual protrusion of the hypocone is the only feature that distinguishes Earendil and Mimatuta according to Van Valen's diagnoses of these genera. The hypocone bulges slightly lingually on UA 16054 although not to the degree in E. undomiel. The angle of the ectoflexus on UA 16054 is seemingly more acute than on M1 of either E. undomiel or M. minuial, a feature characteristic of the Lancian species, Mimatuta morgoth Van Valen 1978. UA 16054 appears relatively more transverse (as is M1, M. minuial) than M1, E. undomiel. The identity of the species represented by the present sample from Long Fall cannot be more refined until additional material is acquired and comparisons can be made directly with Earendil and Mimatuta. The Long Fall species is for the present assigned to the former genus owing to the lingually bulging hypocone on UA 16054.

The Long Fall species becomes the second known Lancian anisonchine in addition to M. morgoth, and is clearly more advanced than that species in known parts of the dentition.

BIOSTRATIGRAPHIC COMPARISONS

Long Fall is undoubtedly of Late Cretaceous (Lancian) age, as is indicated by the presence of dinosaur teeth, as well as by teeth of the marsupial, Pediomys elegans. An adequate sample of mammalian taxa has not yet been recovered from Long Fall, but a cursory comparison with certain assemblages of Lancian and early Paleocene age (see Table 21) indicates overall taxonomic similarity is most evident with the Hell's Hollow local fauna (Archibald 1977), which is currently viewed as being of earliest Paleocene age (W.A. Clemens and J. Archibald 1980, pers. comm.). Although not evident, owing to the format of Table 21, ?Earendil sp. is very similar and undoubtedly closely related to Mimatuta minuial, which is present at Hell's Hollow (Archibald 1980, pers. comm.), and Mantua (Van Valen 1978). Taxonomic lists for Bug Creek Anthills and Harbicht Hill are found in Sloan and Van Valen 1965, Archibald 1977; for Hell's Hollow, Archibald 1977; and for Mantua, Russell 1964, Van Valen 1978.

Rav W-1 (see Table 22) is clearly of Puercan age, as none of the species represented are known from post-Puercan strata. Comparisons with other Puercan localities, however, are hampered by the fact that most localities of Puercan age have been poorly sampled. Taxonomic lists for various Puercan assemblages are provided by Russell (1967) and Van Valen (1978).

The Rav W-1 assemblage appears taxonomically most similar to the Garbani Quarry assemblage (mostly unpublished, W.A. Clemens, in progress) and to a lesser extent, to the Purgatory Hill assemblage. These localities are conventionally viewed as being of late Puercan age (Sloan and Van Valen 1965; Sloan 1969; Sloan 1979, unpubl.), primarily on the

Table 21. Taxonomic comparison of Long Fall assemblage with certain assemblages of latest-Cretaceous and earliest Tertiary age.

Localities: Long Fall	Bug Creek Anthills	Harbicht Hill	Hell's Hollow	Mantua
Taxa				
Cimexomys cf. C. hausoi	G/	G/	cf.	
Mesodma thompsoni	S	S	G/	
Catopsalis cf. C. foliatus	G-	G-	?S	?S
Pediomys elegans	S			
Procerberus cf. P. formicarum	cf.	cf.	cf.	
Protungulatum cf. P. donnae	cf.	cf.	cf.	
?Oxyprimus sp.		?G-	?G-	?G/
Ragnarok sp.		G/	G/	G/
?Earendil sp.				?G/

Key to Symbols:

G: genus occurs in comparative assemblage.

S: species occurs in comparative assemblage.

?: congenerity or conspecifity questionable.

+: morphologically most similar species of genus in comparative assemblage more derived.

-: morphologically most similar species of genus in comparative assemblage less derived.

/: relative primitiveness of morphologically most similar species of genus in comparative assemblage indeterminate.

cf: as conventionally used.

Table 22. Taxonomic comparison of Rav W-1 assemblage with certain assemblages of early Paleocene age.

Localities: Rav W-1	Mantua	Puerco H	Puerco T	Purgatory Hill	Wagon-Road	Dragon
Taxa						
Ptilodus sp.		S		S		
Mesodma formosa		S		S		
Mesodma thompsoni		S		G+		
Ectypodus sp.						
Neoplagiaulax kremnus n. sp.		G-		G+		
Parectypodus armstrongi n. sp.		G/		G/		
Parectypodus sp.		G-		G/		
Xyronomys sp.						
Stygimys camptorhiza n. sp.	G/			G/		
Microcosmodon arcuatus n. sp.						
Taeniolabis sp.			G+	G/	G/	
Purgatorius sp.				G/		
Oxyprimus albertensis	G-			S		
Oxyclaenus corax n. sp.		G/	G/		G/	G+
Loxolophus schizophrenus n. sp.		G+	G+		?G	G+
Baioconodon cf. B. denverensis		G+	G+			
?Eoconodon sp.	?G/	?G/	?G/	?G/		
Anisonchus cf. A. oligistus		G/	G/	cf.	cf.	G+
Bubogonia saskia n. gen., n. sp.						
?Litaletes sp.						
Litomylus orthronepius n. sp.						G+

Key to Symbols: (as in Table 21.)

basis of the supposed presence of Taeniolabis taoensis (Sloan 1980, pers. comm.), which, in the Nacimiento Formation, is restricted to the upper of two faunal zones (the Taeniolabis-zone, Sloan 1969, Van Valen 1978 ["T" in Table 22 (this paper), lower zone, "H"]) recognized in the Puercan interval of the Nacimiento Formation. As pointed out on p. 116 (this paper) the species of Taeniolabis represented at Rav W-1 and Garbani Quarry is not conspecific with T. taoensis and is apparently less derived. This indicatesthat the age of Rav W-1 and Garbani Quarry possibly pre-dates the Taeniolabis-zone of the San Juan Basin. It remains to be demonstrated whether the Taeniolabis species at Purgatory Hill and Wagonroad is conspecific with T. taoensis or with the Garbani Quarry — Rav W-1 species.

LITERATURE CITED

AMEGHINO, F. (1890): Los plagiaulacideos argentinos y sus relaciones zoológicas geológicas, y geográficas. -- Boletín del Instituto geografico argentino, 11: 143-201.

ARCHIBALD, J. D. (1977): Fossil Mammalia and testudines of the Hell Creek Formation, and the geology of Tullock and Hell Creek Formations, Garfield County, Montana. -- Ph.D. thesis, Univ. Calif., Berkeley.

BERRY, E. W. (1935): Floras of the Whitemud and Ravenscrag Formations. -- Geol. Surv., Canada, Mem. 182.

BOWN, T. M. & ROSE, K. D. (1976): New Early Tertiary Primates and a reappraisal of some Plesiadapiformes. -- Folia primatol. 26: 109-138.

BYERS, P. N. (1969): Mineralogy and origin of the upper Eastend and Whitemud Formations of the south-central and southwestern Saskatchewan and southeastern Alberta. -- Can. J. Earth Sci., 6: 317-334.

CLEMENS, W. A. (1963): Fossil mammals of the type Lance Formation, Wyoming: Part I. Introduction and Multituberculata. -- Univ. Calif. Publ. Geol. Sci., 48, 105p.

—,— (1966): Fossil mammals of the type Lance Formation, Wyoming. Part II. Marsupialia. -- Univ. Calif. Publ. Geol. Sci., 62, 122p.

CLEMENS, W. A. (1974): Purgatorius, an early paromomyid primate (Mammalia). -- Science, N.Y., 184: 903-905.

COPE, E. D. (1881): On some Mammalia of the lowest Eocene beds of New Mexico. -- Proc. Amer. Phil. Soc., 19: 484-495.

—,— (1882a): A second genus of Eocene Plagiaulacidae. -- Amer. Nat., 16: 416-417.

—,— (1882b): The classification of the ungulate Mammalia. Proc. Amer. Phil. Soc., 20: 437-438.

—,— (1882c): The Periptychidae. -- Amer. Nat., 16: 832-833.

—,— (1883): On some fossils of the Puerco Formation. -- Proc. Acad. Nat. Sci. Phila.: 168-170.

—,— (1884): Second addition to the knowledge of the Puerco epoch. -- Proc. Amer. Phil. Soc., 21: 309-324.

—,— (1885): The oldest Tertiary Mammalia. -- Amer. Nat., 29: 385-387.

—,— (1888): Synopsis of the vertebrate fauna of the Puerco Series. -- Trans. Amer. Phil. Soc., N.S., 16: 298-361.

FOX, R. C. (1968): A new Paleocene mammal (Condylarthra:Arctocyonidae) from a well in Alberta, Canada. -- J. Mamm., 49, 4: 661-664.

FRASER, F. J., McLEARN, F. H., RUSSELL, L. S., WARREN, P. S. & WICKENDEN, R. T. D. (1935): Geology of southern Saskatchewan. -- Geol. Surv. Canada, Mem. 176: 137p.

FURNIVAL, G. N. (1946): Cypress Lake Map Area, Saskatchewan. -- Geol. Surv. Canada, Mem 242: 121-161.

GAZIN, C. L. (1941): The mammalian faunas of the Paleocene of central Utah, with notes on the geology. -- Proc. U.S. Nat. Mus., 91: 1-53.

GIDLEY, J. W. (1923): Paleocene primates of the Fort Union, with a discussion of the relationships of the Eocene primates. -- Proc. U.S. Nat. Mus., 63: 1-38.

GIEBEL, C. G. (1855): Die Säugethiere. -- Leipzig: 1-1108.

GRANGER, W. & SIMPSON, G. G. (1929): A revision of the Tertiary Multituberculata. -- Bull. Amer. Mus. Nat. Hist., 56: 601-676.

GREGORY, W. K. & SIMPSON, G. G. (1926): Cretaceous mammal skulls from Mongolia. -- Amer. Mus. Novit., 225: 20p.

GULIOV, P. (1972): Lignite coal resources of Saskatchewan. -- In Proc. First Geol. Confer. on western Canadian coal (Mellon, G. B., Kramers, J. W. & Seagel, E. J., eds.). Research Counc. Alberta, Info. ser., 60: 25-29.

HECHT, M. K. (1976): The methodology of phylogenetic inference above the species level. -- In Major patterns in vertebrate evolution (Hecht, M. K., Goody, P. C. & Hecht, B. M., eds.). NATO Advanced Study Institutes Series, Ser. A: Life Sciences: 3-53.

HOLTZMAN, R. C. (1978): Late Paleocene mammals of the Tongue River Formation, Western North Dakota. -- Rept. of Invest. 65, North Dakota Geol. Surv.: 88p.

HOLTZMAN, R. C. & WOLBERG, D. L. (1977): Microcosmodontinae and Microcosmodon woodi, new multituberculate taxa (Mammalia) from the late Paleocene of North America. -- Sci. Pub. Sci. Mus. Minn., 4: 1-13.

JEPSEN, G. L. (1930): Stratigraphy and paleontology of the Paleocene of north-eastern Park County, Wyoming. -- Proc. Amer. Phil. Soc., 49: 463-528.

—,— (1940): Paleocene faunas of the Polecat Bench Formation, Wyoming. -- Proc. Amer. Phil. Soc., 83: 217-341.

JOHNSTON, P. A. (1980): First record of Mesozoic mammals from Saskatchewan. -- (in press) Can. J. Earth Sci.

KIELAN-JAWOROWSKA, Z. (1970): New Upper Cretaceous multituberculate genera from Bayn Dzak, Gobi Desert. -- Palaeontologica Polonica, 21: 37-49.

KIELAN-JAWOROWSKA, Z., BOWN, T. M. & LILLEGRAVEN, J. A. (1979): Eutheria. -- In Mesozoic mammals: the first two thirds of mammalian history (Lillegraven, J. A., Kielan-Jaworowska, Z. & Clemens, W. A., eds.): Berkeley, Univ. California Press: 182-191.

KIELAN-JAWOROWSKA, Z. & SLOAN, R. E. (1979): Catopsalis (Multituberculata) from Asia and North America and the problem of Taeniolabidid dispersal in the Late Cretaceous. -- Palaeontologica Polonica, 24: 187-197.

KRAUSE, D. W. (1977): Paleocene multituberculates (Mammalia) of the Roche Percée local fauna, Ravenscrag Formation, Saskatchewan, Canada. -- Palaeontographica A, 159: 1-36.

—,— (1978): Paleocene primates from western Canada. -- Can. J. Earth Sci., 15: 1250-1271.

KRISHTALKA, L. (1973): Late Paleocene mammals from the Cypress Hills, Alberta. -- Spec. Publ. Mus. Texas Tech. Univ., 2: 1-75.

KRISHTALKA, L., BLACK, C. C. & REIDEL, D. W. (1975): Paleontology and geology of the Badwater Creek area, central Wyoming. Part 10. A late Paleocene mammal fauna from the Shotgun Member of the Fort Union Formation. -- Ann. Carnegie Mus., 45: 179-212.

KUPSCH, W. O. (1956): Geology of eastern Cypress Hills, Saskatchewan. -- Sask. Dept. Mineral Resources, Rept. 20: 30p.

—,— (1957): Frenchman Formation of eastern Cypress Hills, Saskatchewan, Canada. -- Bull. Geol. Soc. Amer., 68: 413-420.

LEMOINE, V. (1882): Sur deux Plagiaulax Tertiaires, recueillis aux environs de Reims. -- C. R. Acad. Sci. 95: 1009-1011.

__,__ (1878): Communication sur les ossements fossiles des terrains tertiaires inferieurs des environs de Reims faite a La Societe d'Histoire Naturelle de Reims. -- Reims, Ann. Sci. Nat. (Paris) 6: 1-56.

MARSH, O. C. (1889): Discovery of Cretaceous Mammalia. -- Amer. J. Sci., Ser. 3, 38: 81-92.

MATTHEW, W. D. (1915): A revision of the lower Eocene Wasatch and Wind River faunas. Part II. Order Condylarthra, Family Hyopsodontidae. -- Bull. Amer. Mus. Nat. Hist., 34: 311-328.

__,__ (1937): Paleocene faunas of the San Juan Basin, New Mexico. -- Trans. Amer. Phil. Soc., 30: 1-510.

MATTHEW, W. D. & GRANGER, W. (1921): New genera of Paleocene mammals. -- Amer. Mus. Novit. 13: 1-17.

McKENNA, M. C. (1960): The Geolabinidae, a new subfamily of early Cenozoic erinaceoid insectivores. -- Univ. Calif. Publ. Geol. Sci., 37: 131-164.

McLEARN, F. H. (1928): Stratigraphy, structure, and clay deposits of Eastend area, Cypress Hills. Saskatchewan. -- Geol. Surv. Canada, Summ. Rept., 1927, Pt. B: 21-43.

__,__ (1929): Southern Saskatchewan. -- Geol. Surv. Canada, Summ. Rept., 1928, Pt. B: 30-44.

__,__ (1930): Stratigraphy, clay and coal deposits of southern Saskatchewan. -- Geol. Surv. Canada, Summ. Rept., 1929, Pt. B: 48-64.

MISKO, R. E. & HENDRY, H. E. (1979): The petrology of sands in the uppermost Cretaceous and Paleocene of southern Saskatchewan: a

study of composition influenced by grain size, source area, and tectonics. -- Can. J. Earth Sci., 16: 38-49.

MURRAY, A. (1866): The geographic distribution of mammals. -- 420p. Day and Son Ltd., London.

NOVACEK, M. & CLEMENS, W. A. (1977): Aspects of intrageneric variation and evolution of Mesodma (Multituberculata, Mammalia). -- J. Paleont., 51: 701-717.

OSBORN, H. F. & EARLE, C. (1895): Fossil mammals of the Puerco beds. -- Coll. of 1892 Bull. Amer. Mus. Nat. Hist., 7: 1-70.

RAHMANI, R. A. & LERBEKMO, J. F. (1975): Heavy mineral analysis of Upper Cretaceous and Paleocene sandstones in Alberta and adjacent areas of Saskatchewan. -- In The Cretaceous System in the Western Interior of North America (Caldwell, W. G. E., ed.). Geol. Assoc. Can., Spec. Pap. 13: 607-632.

RIGBY, J. K., Jr. (1980): Swain Quarry of the Fort Union Formation, middle Paleocene (Torrejonian), Carbon County, Wyoming: geologic setting and mammalian fauns. -- Evol. Monogr., 3: 179p.

RUSSELL, D. E. (1964): Les Mammiferes Paleocenes d'Europe: -- Mem. Mus. Nat. Hist. Nat., Ser. C., 13: 324p.

—,— (1967): Le Paleocene Continental d'Amerique Du Nord. -- Mem. Mus. Nation. Hist. Nat., Ser. C, t. 16: 99p.

RUSSELL, L. S. (1926): A new species of the genus Catopsalis Cope from the Paskapoo Formation of Alberta. -- Amer. J. Sci., 12: 230-234.

—,— (1932): The Cretaceous Tertiary transition of Alberta. -- Roy. Soc. Canada Trans., ser. 3, 26: 121-156.

—,-- (1943): Marine fauna of the Eastend Formation of Saskatchewan. -- J. Palaeont., 17: 281-288.

—,— (1950): Correlation of the Cretaceous-Tertiary transition in Saskatchewan and Alberta. -- Bull. Geol. Soc. Amer., 61: 27-42.

—,— (1951): The geology of the southern part of the Cypress Hills, southwestern Saskatchewan. -- Sask. Dept. Mineral Resources, Rept. 8: 58p.

—,— (1958): Paleocene mammal teeth from Alberta. -- Nat. Mus. Can. Bull., 147: 96-103.

—,— (1965a): Macropaleontology of the surface formations, Cypress Hills area, Alberta and Saskatchewan. -- In 15th Ann. Field Conf. Guidebook, Alberta Soc. Petro. Geol., Pt. 1: 131-136.

—,— (1965b): The continental Tertiary of Western Canada, -- Dept. of Geol., Univ. of Alberta, Edmonton, Bull. 2: 41-52.

—,— (1974): Fauna and correlation of the Ravenscrag Formation (Paleocene) of southwestern Saskatchewan. -- Roy. Ont. Mus., Life Sci. Contri., 102: 1-53.

RUSSELL, L. S. & LANDES, R. W. (1940): Geology of southern Alberta plains. -- Geol. Surv. Can., Mem. 221: 1-223.

SCHIEBOUT, J. A. (1974): Vertebrate paleontology and paleoecology of Paleocene Black Peaks Formation, Big Bend National Park, Texas. -- Tex. Mem. Mus. Bull., 24: 1-88.

SCOTT, W. B. (1892): A revision of the North American Creodonta, with notes on some genera which have been referred to that group. -- Proc. Acad. Nat. Sci. Phila.: 291-323.

SIMPSON, G. G. (1925): A Mesozoic mammal skull from Mongolia. -- Amer. Mus. Novit., 201: 1-11.

—,— (1927): Mammalian fauna of the Hell Creek Formation of Montana. -- Amer. Mus. Novit., 267: 1-7.

—,— (1935a): New Paleocene mammals from the Fort Union of Montana. -- Proc. U.S. Natl. Mus., 83: 221-244.

—,— (1935b): The Tiffany fauna, Upper Paleocene. III. Primates, Carnivora, Condylarthra, and Amblypoda. -- Amer. Mus. Novit., 817: 1-28.

—,— (1936a): A new fauna from the Fort Union of Montana. -- Amer. Mus. Novit., 873: 1-27.

—,— (1936b): Additions to the Puerco fauna, Lower Paleocene. -- Amer. Mus. Novit., 849: 1-11.

—,— (1937): The Fort Union of the Crazy Mountain field, Montana and its mammalian faunas. -- U.S. Natl. Mus. Bull. 169: 287p.

SLOAN, R. E. (1969): Cretaceous and Paleocene terrestrial communities of western North America. -- Proc. N. Amer. Paleo. Conv., Part E: 427-453.

—,— (1980): Paleocene multituberculates from the San Juan Basin, New Mexico. -- In press.

SLOAN, R. E. & VAN VALEN, L. (1965): Cretaceous mammals from Montana. -- Science, 148: 220-227.

STERNBERG, C. M. (1924): Notes on the Lance Formation of southern Saskatchewan. -- Can. Field-Nat., 38: 66-70.

—,— (1932): A new fossil crocodile from Saskatchewan. -- Can. Field-Nat., 46: 128-133.

SWEET, A. R. (1978): Palynology of the Ravenscrag and Frenchman formations. -- In Coal Resources of southern Saskatchewan, a model

for evaluation methodology (Irvine, J. A., Whitaker, S. H. & Broughton, P. L., eds.). Geol. Surv. Can. Ec. Geol. Rept. 30: 29-39.

TROUESSART, E. L. (1897): Catalogue mammalium tam viventium quam fossilium. -- 1264p. R. Friedlander und Sohn, Berlin.

—,— (1904): Catalogus mammalium tam viventium quam fossilium. Supplement, pts. 1-2: 546p.

VAN VALEN, L. (1978): The beginning of the Age of Mammals. -- Evol. Theory, 4: 45-80.

VAN VALEN, L. & R. E. SLOAN (1965): The earliest primates. -- Science, 150: 743-745.

—,— & —,— (1966): The extinction of the multituberculates. -- Syst. Zool., 15: 261-278.

WHITAKER, S. H. (1972): Lignite exploration in the Ravenscrag Formation of southern Saskatchewan. -- In Proc. First Geol. Conf. on western Canadian coal (Mellan, G. B., Kramers, J. W. & Seagel, E. J., eds.). Research Counc. Alberta, Info. ser. 60: 25-29.

—,— (1978): Regional Geology. -- In Coal Resources of southern Saskatchewan, a model for evaluation methodology (Irvine, J. A., Whitaker, S. H. & Broughton, P. L., eds.). Geol. Surv. Can. Ec. Geol. Rept. 20: 21-27.

WINGE, H. (1917): Udsigt over Insektaedernes indbyrdes Slaegtskab. -- Vidensk. Meddel. Dansk. Naturh. Foren., 68: 83-203.

ZITTEL, K. A. von (1893): Handbuch der Palaeontologie. I. -- Abth. Palaezoologie. 4 Band. Vertebrata (Mammalia). 799p. Munich and Leipzig.